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Implementing lean in healthcare warehouse operations - evaluation of 5S best practice

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**IMPLEMENTING LEAN IN HEALTHCARE WAREHOUSE OPERATIONS –
EVALUATION OF 5S BEST PRACTICE**

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Science in Industrial Engineering

in

The Department of Construction Management and Industrial Engineering

by
Sanjith Venkateswaran
B.E., P.S.G. College of Technology, India, 2008
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ABSTRACT

Lean strategies in healthcare aim at improving patient throughput, reducing medication errors, redesigning work flow, improving patient safety, and reducing cycle time. Documented studies to improve healthcare's warehouse operation are not common in the literature. Managing types of medical supplies has always been a priority due to demand uncertainties and the risk of shortages that would profoundly affect patient safety. This study showcases two implementation approaches for the Lean tool 5S (Hybrid and Traditional) conducted in three different hospitals' central warehouses at Ochsner Health System. These warehouses store similar medical products with over 1000 types of supplies (e.g. syringes, gloves, primary IV) that supply different departments within hospitals and clinics. The participating warehouses faced similar problems due to over/under stocked inventories, space constraints, and poor layouts. The objective of this study was to compare the impact of implementing a Hybrid 5S (integrated with inventory management techniques and process improvement tools) along with two Traditional 5S's to improve healthcare warehouse operations. Although the two approaches improved the baseline warehouse process, the warehouse that used the Hybrid 5S showed the greatest improvement with an increase of 59.5% in inventory turnover, 15.7% space saved, and least number of non-conformities in the 5S audit tool.

CHAPTER 1: INTRODUCTION

1.1 Motivation

Implementation of Lean in the healthcare field has been growing due to its past success in manufacturing and automobile sectors. George (2003) considered three reasons for implementing Lean in the service industry including large work in progress (WIP), low quality and higher expenditures. Applying Lean has always been challenging in healthcare, especially while addressing the needs and safety of a patient that can produce adverse effects. Currently, the implementation of Lean has become popular among the healthcare industry, where several hospitals are striving to provide the best care for their patients and attain error-proofed processes.

Over the past several years, researchers have strived to address the problems in healthcare and provide solutions by adopting various methods and techniques. For instance, Koning et al. (2006) described that one of the significant contributor to healthcare cost is operational inefficiency, such as medical service delivery and operation of healthcare delivery system. Endsley et al. (2006) considered output (wrong process, over-production, delay, large variation in output rate and demand) and flow (waiting, duplication of process, rework, work interruptions, and non-standardized work) as the two main categories for problems in medical practices. However, the healthcare faces other problems such as improving the patient throughput, patient scheduling, and increasing process efficiency. Managing types of medical supplies also plays a vital role. This has always been a priority due to demand uncertainties and the risk of shortages in life-threatening situations.

Graban (2008) reported frequent problems in handling supplies/equipment in healthcare that add to non-value added activities such as; 1) delays in delivery of supplies due to improper ordering, 2) mix ups in getting supplies, 3) returns by departments due to defects, 4) difficulties in handling new

equipment, 5) effective utilization of space. This research strives to address issues 1, 2, and 5 by implementing Lean tools and strategies, especially 5S.

1.2 Significance

The current research showcases Lean tools and strategies to improve healthcare warehouse operations. This research also studied the effectiveness of a new concept - Hybrid 5S, which is capable of reducing the overall inventory and streamlining supplies by adopting a set of process improvement and inventory management tools combined with Traditional 5S. In order to evaluate the impact of the Hybrid 5S, a comparison analysis was performed with results from two other warehouses' adopting Traditional 5S. The comparison analysis focused on the 5S audit as the evaluation metric to assess the best approach.

Lean tools and strategies in healthcare aim at improving patient throughput, reducing medication errors, redesigning work flow, improving patient safety, and reducing cycle time. An elaborate study, which focuses on improving healthcare warehouse operations, has not been performed in the past. This study encompasses a greater level of detail to assess the impact of the Hybrid 5S by identifying critical supplies, reducing the overall inventory, redesigning the warehouse layout, optimizing the space, and reducing the distance travelled. Hybrid 5S approach was developed through an extensive literature review of the Lean tool, Kaizen; and establishing the relationship between process improvement tools and inventory management techniques.

1.3 Lean in Healthcare and Kaizen Events

Lean production has shown a wide range of implementation in aerospace, chemical refineries, financial services, insurance and other industries. A rapid demand for Lean in healthcare is growing due to its systematic approach to improving quality, safety and efficiency (Kim et al., 2006). According to King et al. (2006) one of the main aspects of Lean thinking is the understanding of a

complex process instead of starting with an assumed solution. Various Lean tools such as Kaizen and 5S follow a structured methodology to understand and arrive at a possible solution to a given problem. Kaizen is a Japanese philosophy which is based upon the principle of continuous improvement that emphasizes low cost and low-risk improvements (Jacobson et al., 2009).

1.4 Inventory Management

Kilpatrick (2003) emphasized the need for Lean Production system to eliminate the seven different kinds of wastes. Out of these seven wastes, excess inventory, negatively impacts the cash flow and results in usage of excess space. According to Graban (2008), manufacturing companies tend to think that performing Lean is the process of achieving low inventory but its primary goal is to satisfy the patients in the process of maintaining low inventory. In the past Lean has witnessed great response from diverse fields due to its positive impact. For instance, Kumar et al., (2006) by implementing Lean enabled Small Medium Enterprises (SME) to eliminate defects, reduce variation and most importantly, reduce inventory. Inventory management has seen increased application in recent times with the development of various inventory control and management techniques. One such technique is the ABC classification (adopted from the Pareto principle) that is mainly used to classify supplies as Class A supplies (fewer in number but with a larger annual sales value), Class B supplies (moderate number of supplies with a moderate annual sales value), and Class C supplies (with larger supplies and little annual sales value) (Ramanathan, 2006).

However, Traditional healthcare system has not shown enough attention to manage inventories and in most cases, it has been politically driven or by the individual's experience rather than relying on historical data (Nicholson et al., 2004). Even though, past studies discussed the role of Lean in reducing excess inventory, it has failed to mention practices that can effectively manage inventory levels and provide a suitable environment that can be sustained for the future.

1.5 Traditional 5S

Dulhai (2008) suggested that 5S rules have immediate and significant effects on the sequence of activities, thus influencing the performance of processes in the company. 5S is a sequence of activities (sort, set to order, shine, standardize, and sustain) that is an effective tool for housekeeping or organization of supplies in healthcare. Sun and Yanagawa (2006) conducted a project by implementing 5S and one-piece flow to improve the services of the college union in an institute. Although, Traditional 5S has been an effective tool in organizing and maintaining a suitable work environment, studies show that emphasis was given to monetary gains rather than arriving at a self sustained approach which will be able to identify root causes and provide solutions to excess inventory issues.

1.6 Hybrid 5S Model

The Hybrid 5S model is based upon the Deming's cycle, or the PDCA cycle of Kaizen (Kanji 1996), which integrates process improvement tools with inventory management techniques. The implementation of the Hybrid 5S model entails four phases: 1) Observation and preparation, 2) Planning Lean initiatives, 3) Implementation, and 4) Measurement of improved process.

1.7 Research Objective

The objective of this study was to implement, document and evaluate the impact of implementing a Hybrid 5S strategy, which is integration of inventory management techniques and process improvement tools. Results from the Hybrid 5S implementation were compared with results from two other implementations of the Traditional 5S on hospital warehouses operations. The performance metrics included evaluating improvements on monthly inventory turnovers after the implementation of the 5S strategies and comparing the three hospital warehouses using the ratings on the 5S audit. Based on the outcome of the comparison evaluation, a set of guidelines was developed for an effective implementation of the Lean tool 5S for healthcare warehouse operations.

1.8 Warehouse Characteristics

This study was conducted at three hospital's central warehouses of a leading healthcare unit in the southern region of the United States. The three warehouses store over 1100 types of medical supplies (e.g. syringes, gloves, primary IV) for different hospital's departments and clinics. The process of ordering supplies between the central warehouse and vendors has been carried out electronically using the software application called LAWSON. The process of ordering and receiving the supplies is shown in the Figure 1.1.

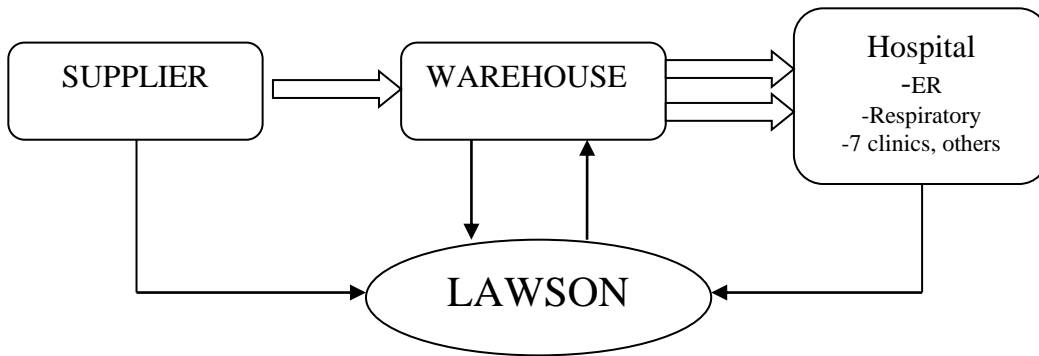


Figure 1.1. Ordering and Receiving policy

LAWSON contains a detailed history of each supply stored in the central warehouse, including demand of each month, supply cost, current stock, and vendor information. LAWSON also has the provision to maintain the inventory of each supply and the ability to calculate the economic order quantity (EOQ) and re-order level (ROL) using predefined formulas.

1.9 Research Methodology

The practice of inventory management, at the three warehouses, was based on experience of one or more warehouse's employees. In addition, the warehouses were facing problems due to excess inventory, space constraints, and layout issues. These issues were addressed by implementing 5S techniques to organize and effectively manage hospital supplies.

The Hybrid and Traditional 5S were implemented and results documented. To evaluate improvements of the two 5S methods, statistical hypothesis testing and ANOVA was performed using SAS 9.2 (Statistical Analysis Software). Then, a modified 5S audit tool (Ho, 1999) was used to evaluate the sustainability of each 5S approach. Then, a comparison analysis was performed among results from the Hybrid 5S implementation and results from the two other implementations of the Traditional 5S on hospital warehouses operations. The performance metrics used to compare and evaluate the implementation results included the improvement on monthly inventory turnovers and ratings on the 5S audit. Finally, results and lessons learned from these 5S implementations were used to develop guidelines to integrate inventory management techniques and 5S to improve hospital warehouse operations.

1.10 Research Limitations

The major limitation in this research was gathering historical usage data of supplies from the hospital and clinics, which forced the use of a deterministic rather than probabilistic inventory model. For future research, the implementation of a probabilistic inventory model will be more beneficial since it would consider the effects of any seasonal and uncertain demands. The inventory model implemented assumed that the demand remained constant throughout the year. The influence of the number of beds in a hospital facility was not considered. Seasonal demand of supplies during natural or anthropogenic calamities was not considered. These issues ought to be addressed in order to overcome the limitations in this research. The inventory turnover was not normalized with respect to the number of patients due to unavailability of patient census. Some of the possible confounding factors that were not addressed in the 5S Audit survey include the differences between the raters who audited the warehouse and influence due to the lack of employee cooperation and adaptability.

CHAPTER 2: BACKGROUND AND LITERATURE REVIEW

2.1 Lean in Health Care (HC): An Overview

Toyota Production System (TPS), which is often, referred to as Lean Manufacturing focuses on reducing waste, synchronizing and managing work flows by integrating system of tools, practices, principles, and techniques (Koning et al., 2006). Lean production is a management philosophy that combines models such as Total Quality Management (TQM), and Continuous Quality Improvement (CQI) developed by W.E. Deming (Kim et. al, 2006). After its considerable impact in the manufacturing sector, Lean has shown a tremendous growth in healthcare. To demonstrate the origin of Lean in healthcare, Graban (2008) argues that Lean methods are not new to healthcare for which he stated the work of Frank, Lillian Gilbert, and Henry Ford in early nineties that industrial engineering methods could be applied to hospitals. Graban (2008) in his book mentions the work of Henry Ford in 1922, where he emphasizes the need to put patient interests first and eliminate waste movement in the hospital.

Past researches have discussed in detail about the importance of Lean in healthcare. Kim et al. (2006) discussed the growing response of Lean in healthcare adopting a systematic approach to improve their quality and efficiency. Most of the previous research is focused on the transformation of Lean from its manufacturing implications to healthcare. For instance, Kim et al. (2006) suggested that;

“Lean techniques will have widespread use of its management philosophy and operational concepts from the manufacturing sector to healthcare provided they address the cultural and practical barriers that are likely to occur during the implementation”

They stressed the need to oversee organizational, professional and cultural differences that separate the healthcare industry from other sectors that have incorporated Lean into their practices. Womack et al. (2005) argued that Lean could be implemented in a service industry even though it was first developed for the manufacturing industry. He argues that whether it is a service or a product

oriented industry, the employee is required to accomplish a set of processes and actions, in order to provide value for the customer or the patient. Zidel (2006) argued that;

“Hospitals cannot continue to operate as they have in the past because insurance companies were not willing to pay for the non-value added activity associated with hospital processes.”

The main purpose of implementing Lean is to reduce the wastes due to defects, over processing, over production, excess motion, travel, inventories, and waiting. While competing against external problems such as reimbursement issues, staffing shortages, rising costs and the increase of physician owned ambulatory care facilities; hospitals should take necessary measures to address these wastes (Zidel, 2006).

In the research, conducted by Cooper and Mohabeersingh (2008) they stated that the purpose of Lean thinking in healthcare included identifying patient value, evaluating its efficiency and management of the value stream. Their idea of Lean thinking is that it should be considered as a process based method and accounting for interactions across the entire supply chain. In addition, stresses the importance of working together and promoting teamwork with the primary goal of satisfying patient's needs.

Several Lean tools and techniques have been utilized in the past for a successful understanding of a process flow in order to provide solutions to address an issue. Zidel (2006) presented some of the basic tools used in Lean transformation for a healthcare setting. He adopted 5 simple Lean tools and techniques such as 5 why's, 5S, Kanban, visual controls and standard work which can help any organization to launch its Lean transformation. Kumar et al. (2006) discussed the tools and techniques that have been used for the successful implementation of Lean and removal of the seven types of waste (as shown in figure 2.1).

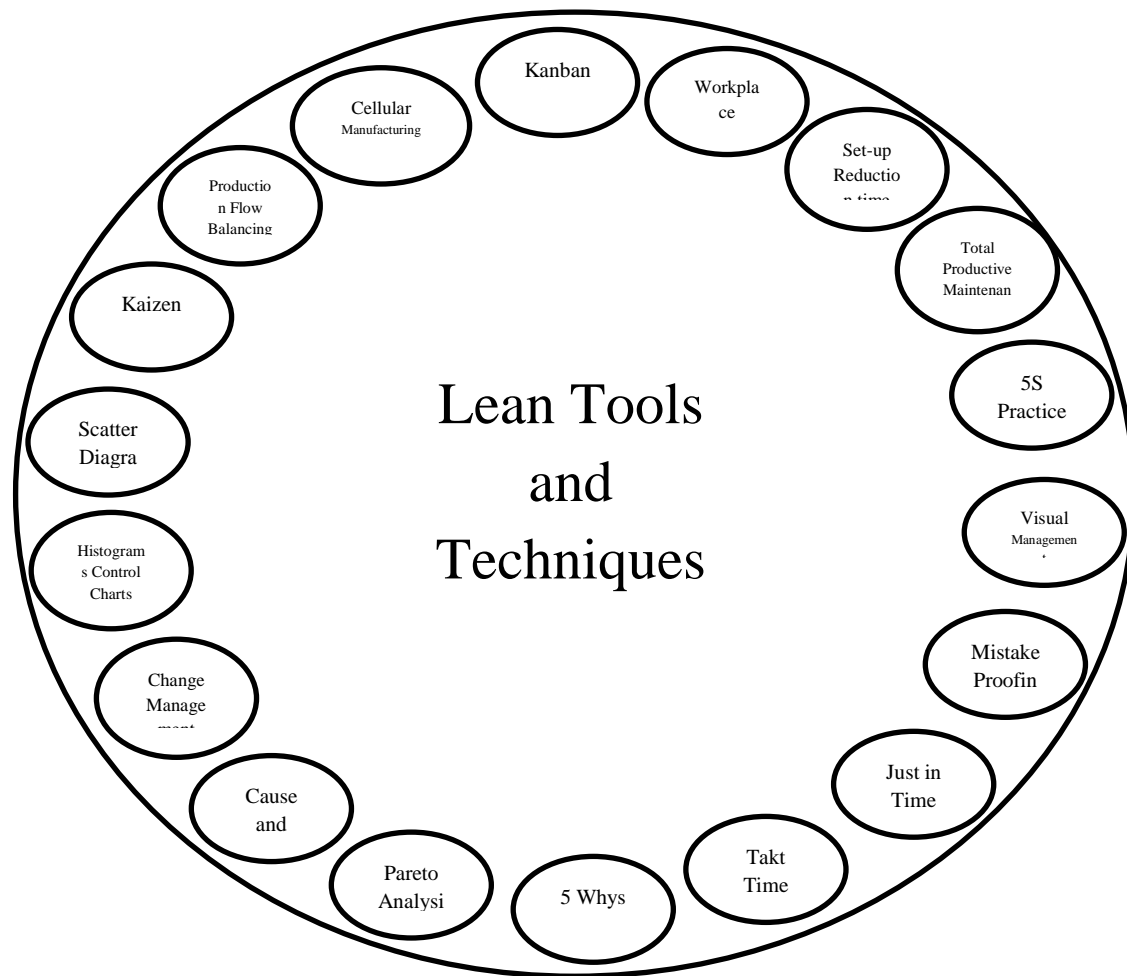


Figure 2.1. Tools and Techniques in Lean [Adopted from Kumar et al., (2006)]

Jimmerson et al. (2005) suggested that Lean tools and principles are applicable to healthcare for addressing challenges in reducing errors, costs, and shortages. However, the effective means of implementation involve adopting the right tools and techniques best suited for the organization.

Lean implementation has enormous benefits in various activities of healthcare. For instance, study conducted by Weinstock (2008) lead Lean practice to minimize the patient wait times, increase speed of room turnover, increase charting accuracy, inventory control and revenue. Study performed by Wojtys et al. (2009) applied Lean techniques to improve patient scheduling process with the help of Lean tools that evaluated their current scheduling system, remove wasteful processes and procedures

resulting in an efficient and effective system. Patient satisfaction surveys yielded positive results as a result of their work. Kim et al. (2006) stated examples on how Lean in healthcare was implemented in the past where one of the hospitals witnessed a decline in the incidences of diseases. This led to a cost reduction of nearly half a million dollars improving their productivity by decreasing the number of medication errors also reducing the delays.

Zidel (2006) in his study reported that hospital quality levels can improve significantly, and huge cost savings can be realized by reducing the percentage of non-value added work, this could then be redistributed to other quality initiatives. Cooper and Mohabeersingh (2008) realized by adopting Lean strategies accelerated patient's throughput. It provided them a tool to resolve inefficiencies, reduce in cost and achieve a higher turn around using the same staff and processes. They also insisted that a part of the annual profit should be provided for improvements in practice. This can encourage employees to value existing work process and provide services that ensure practice viability.

The advantage of a product-oriented industry is the ability to provide quality products subjected to product's specifications, but the difficulty in healthcare is the measure of patient satisfaction that is not a simple task (Ford et al., 1997). Lean is often associated with the pull strategy, but in the service sector, the pull strategy is built during the interaction between the patient and provider that cannot be used in the future (Kollberg et al., 2006).

For a successful implementation of Lean, several challenges have to be addressed, for instance, the ability of a worker to identify waste and flexibility to accept changes (Womack et al., 2005). Cooper and Mohabeersingh (2008) identified some of the common issues such as organizational resistance to change and entrenched ways of thinking amongst healthcare workers that need to be addressed in order to find the right balance between innovation and complexity.

Since, this research is more inclined towards managing healthcare supplies, past research, especially in the case of Graban (2008), in his study listed frequent problems in handling supplies/equipment in healthcare. This adds to non-value added activity such as; 1) delays in delivery of supplies due to improper ordering, 2) mix ups in getting supplies, 3) returns by departments due to defects, 4) difficulties in handling new type equipment, 5) effective utilization of space. This research strives to address the problems stated in (1), (2), and (5). However, an extensive research was not performed to assess an implementation strategy using Lean tools and techniques to a warehouse of a healthcare facility. Previous studies failed to identify Lean tools and techniques best suited for an organization instead followed a traditional method of applying Lean to a process.

2.2 Lean and Inventory Management

Fine et al. (2009) defined wastes due to inventory as when materials/supplies are retained for a period, which not only includes warehouse stock, but also work in process supplies. Smith (2003) suggested that the Lean tool Kaizen, integrate principles of total production system and creates a one-piece flow for inventory management. The study conducted by Smith (2003) witnessed a 5-day Kaizen event where cross functional groups strived to improve lead-time and reduce inventory on the spot eliminating quality and flow issues.

Weinstock (2008) states that inventory should not be more than that needed for a product and the supply should be restocked once it is utilized. It is also necessary for any organization to determine the exact amount of stock on hand and replenish the right quantity once it reaches its re-order level. Kumar et al. (2006) illustrated that the increase in inventory would lead to higher inventory carrying cost hence by implementing Lean in an organization will reduce the defects, work-in-progress inventory, scrap, and rework cost.

Several inventory management techniques practiced in the past addresses inventory issues. A greater level of understanding and attacking inventories was studied in detail under “Supply Chain Management”. Minner (2003) defined supply chain management as;

“An integrative approach for planning and control of materials and information flows with suppliers and customers as well as between different functions within a company”.

Various tools and techniques have evolved in the past displaying the importance and the need for addressing inventory. One such technique, called as the ABC classification, is widely used to classify the supply that enables to identify the critical and least important supplies. The classical ABC classification was developed at General Electric during the 1950's that are based on the Pareto principle developed by an economist Ville Farado Pareto of the 18th century who stated that 20% of the people controlled 80% of the wealth (Guvenir and Erel, 1998).

Guvenir and Erel (1998) suggested that companies dealing with the burden of a large number of supplies companies must classify the supplies in inventory and develop suitable inventory control policies for these classes. Guvenir and Erel (1998) in their paper discussed the methodology involved in applying ABC classification. The relatively small number of supplies at the top of the list controlling the majority of the total annual dollar usage constitutes a class ‘A’ which can also be denoted as, 20% of the supplies that constitute 80% of the overall inventory value are termed as class ‘A’. The majority of supplies at the bottom that controls a relatively small portion of total annual dollar usage constitute class ‘C’. The supplies between the above classes constitute class ‘B’. Finally, the supplies are ordered in descending order based on their annual dollar usage values which are the products of annual usage quantities and the average unit prices of the supplies (Guvenir and Erel, 1998).

The outcome of ABC classification enables us to provide effective means of control in ordering procedures and focus on the demand forecast class 'A' supplies. In-Contrast Class 'C' supplies receive the least importance, and class 'B' supplies a moderate importance in the control measures, and the outcome could lead to substantial savings (Guvénir and Erel, 1998). Several inventory techniques are in practice today either deterministic or probabilistic but to arrive at a suitable technique depends on the nature of the organization. Inventory models are based on historical data to determine the quantity, and frequency of replenishment derived from the Economic Order Quantity (EOQ) and the Re Order Level (ROL) formulas have been applied by organizations (Martinennly, 2008).

Kelle et al. (2009) provided insights of inventory management in the healthcare industry that poses challenges both from managerial and operational perspective. One of the major issues that healthcare faces are in its difficulty to determine the actual demand for a supply. Forecasting techniques may not prove to be worthy due to its nature of uncertainty and seasonal demand. Running out of supplies may produce adverse effects in providing care to a patient. Healthcare industry can only project production outputs based on their daily schedule rather than a forecasted data (Martinennly, 2008).

Kelle et al. (2009) in their study concluded that healthcare, unlike other industries, has not given the detailed attention for supply chain management that is necessary, in addition to ensuring patient safety, and reduction of overall healthcare costs. Another study conducted by Martinennly (2008) also suggested that healthcare must maintain distribution and inventory systems similar to those in the manufacturing industry since the major issue in par levels is that these levels tend to reflect the desired inventory levels of patient care givers instead of the actual inventory levels needed in a department. Their study emphasized that past researchers have not attempted to examine the logistical

operations; the healthcare providers show least importance to par levels where healthcare inventories account to 50,000 to 400,000 of stock keeping units and the product requirements change frequently.

Kelle et al. (2009) recognized the stakeholder relationships; product consideration and managerial and regulatory policies were unique and typically seen in healthcare. He concluded that investigating the inventory control issues or demand characteristics are of lesser importance than identifying the magnitude of the industry. The outcome of maintaining excess inventory could lead to other issues such as holding costs and space constraints. Martinennly (2008) in his study discussed this aspect where he mentions that hospitals in most cases are constrained due to lack of space forcing them to order less which is also experience based or politically driven inventory control practice that leads them to overstocking some of the supplies.

From, the extensive research conducted it is seen that not much of an emphasis was made to address the inventory of an organization using Lean initiatives. However, studies included the importance of addressing the inventory for an organization but an effort was not made in carrying out a Lean event in real-time application. Considering the amount of research carried out in development of several inventory control techniques, it will be interesting to find out the impact on integrating Lean and inventory management techniques.

2.3 Traditional 5S

5S is a systematic Lean tool and the simplest to implement for organizing and standardizing the workplace (Kilpatrick, 2003). Ho (1999) described 5S practice as a technique to establish and maintain a quality environment in an organization. 5S stands for five Japanese words, Seiri, Seiton, Seiso, Seiketsu and Shitusuke that is a technique practiced in Japan for a long time. Most Japanese 5S professionals consider the 5S not only improves the physical environment but also the thinking processes (Ho, 1999). After its immense popularity in Japan, its benefits spread across the western

countries and translated in English. For instance, Ho (1999) provided English translation for the 5S such as structurize, systematize, sanitize, standardize, and self-discipline. According to Zidel (2006), he termed the 5S event as sort, straighten, scrub, standardize and sustain. Other names such as sort, set to order, shine, standardize and sustain have also been used in most cases (Jackson, 2009).

5S implementation has seen in diverse fields due to its simple and immediate results. As described by Kilpatrick (2003), 5S provides immediate returns on investment and is applicable to a diverse function of organizations. In the past, several organizations have successfully implemented 5S. Researchers have shared their experience during the implementation of 5S and its impact after the event. Zidel (2006) suggested that 5S creates a solid foundation for future Lean initiative and can be implemented by any organization. Esain et al. (2008) identified 5S as a structural method to speed up operational change and focused on overseeing workplace discipline and control. Similarly, the study conducted by Khamis et. al (2009) also focused on a structural method (Figure. 2.2) to transform the 5S process by providing adequate training to the employees starting with input for 5S to the result.

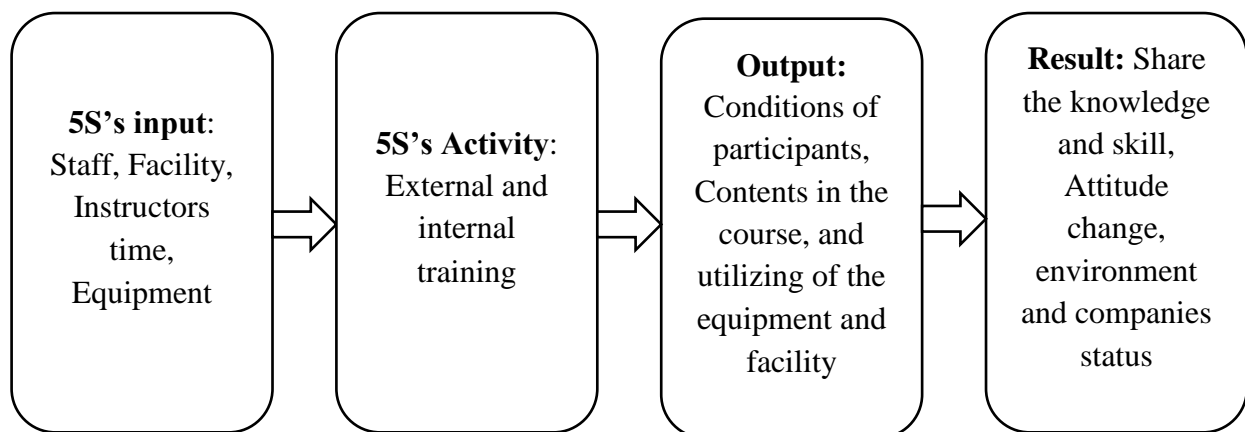


Figure 2.2. 5S Transformation Process (Source: Khamis et. al, 2009)

Zidel (2006) describes the 5S event as a sequence of activities starting with 'Sort' where one gets rid of everything that is not used or will not be used in the next couple of weeks. Esain et al.

(2008) suggested sorting out necessary supplies in an area, and the unnecessary supplies are disposed or moved. Sort separates things that are not essential and ensures that supplies are easy to retrieve by classifying them which enables decision making on the importance of the supply and finally helps to discard unnecessary supplies, in doing so, reducing the inventory (Pheng and Khoo, 2001).

Zidel (2006) termed straightening as a means to organize supplies, which are kept, allocation of space for these supplies and ensure that they are placed in the right place. He emphasized that an enormous amount of wastes are associated in looking up supplies and can be considerably reduced or even eliminated by organizing them. For better organization of workplace, Esain et al. (2008) suggested the first step is determining the volume of use of a supply and placing frequently used supplies close to a workstation that can considerably reduce excess travel. Pheng and Khoo (2001) in their implementation of 'Set to Order' focused on the layout and structure of a workplace that involves where and how the necessary supplies are placed. The outcome was highlighted which enable them to identify and remove wastes with ease.

Another important aspect of the Set to Order stage is to arrive at decisions that must be made in order to make the storage location centralized or decentralized (Pheng and Khoo, 2001). These decisions are based on usage, frequency, and function of the supplies that influence the placement of supplies that are needed, easily noticed, and accessible without obstructing work processes (Pheng and Khoo, 2001). Pheng and Khoo (2001) argued that other than storage attention should also be given to 1) aspects of layout 2) position & height of the tools and equipment's (to maintain good posture for employees) 3) proper system of labeling 4) identifying work process flows that everyone can understand, follow and maintain.

Zidel (2006) defined shine in the workplace as cleaning the area that is visible to everyone. Esain et al. (2008) emphasized the importance of making sure that all supplies are in the best working

conditions and remain so. Similarly, Pheng and Khoo (2001) carried out an effective ‘Shine’ 5S event by 1) maintaining good image of cleanliness, 2) assigning individual responsibility for cleaning, 3) discarding out unnecessary things, 4) visibility in tracking problems, 4) daily inspection, 5) lubrication and cleaning equipment which is a part of preventive maintenance.

Zidel (2006) referred standardization as to establishing procedures to keep the area organized. This fourth phase also enables to standardize work routines such as equipment and material usage (Esain et al. (2008). According to Jackson (2009) standardize integrates sort, set-in-order and shine into whole unit. He listed some of the problems that can be avoided by implementing standardize activities such as 1) Conditions do not go back to their old, undesirable levels even after a major 5S implementation campaign, 2) Unnecessary supplies are not discarded from the day’s work and found scattered around the work place, 3) Tool storage areas more organized and put back in order at the end of the day. Another important aspect of standardization is that it helps to create transparency in a process (Pheng and Khoo, 2001). Some of the tools used for standardization, as discussed by Jackson (2009) are checklists, visual 5S, 5S maps, 5S schedules and 5S job cycle charts.

Zidel (2006) termed the final event sustain as that involves maintaining the gains and prevent backsliding. This is more to ensure that the standards are set, followed and improved (Esain et al., 2008). Pheng and Khoo (2001) stressed on discipline that involves training, good habits, which ensures that, the former 4-S are carried out perfectly. Similarly, Ho (1999) identified sustain as a practice of discipline in day-to-day activities.

Traditional 5S has showed the importance of incorporating 5S in day-to-day activities that ensure an error-free process. Past studies have paved way for an effective way in conducting a 5S event and the necessary goals to be achieved. However, a major weakness is that most of the papers emphasized more on sharing ideas and ways to beautify a workplace, rather than achieving quality. In

addition, studies have not been performed on the incorporation of various other process improvement tools and procedures to address issues such as inventories, layout redesign, and employee satisfaction. Studies reflect a monotonous way of implementing traditional techniques that are irrelevant and may not provide the desired results at current conditions.

2.4 5S Audit

An audit tool is essential to identify whether the implementation has been undertaken correctly and enables to detect issues that can be immediately dealt with by providing suitable solutions. Several 5S audit tools are available in the literature that provides a quick check on the 5S implementation process. For instance, Khamis et. al (2009) focused on developing a 5S practice checklist for the manufacturing industry by conducting surveys with two companies by considering housekeeping, environmental performance, health and safety, and analyzing the checklist record. They used two ranking systems for analyzing the condition of the companies in this study that are Likert scale and percentage value. The Likert Scale used in their study was to determine the level of implementation of the 5S practice for each aspect in a developed checklist with 5 being the highest and 1 the lowest (Khamis et. al, 2009).

Ho (1999) developed the idea of introducing a 5S audit tool that effectively deals with identifying the non-conformance in an organization. This tool has been designed to suit any organization, by means of 50 questions for the five stages of 5S, which are Sort, Set-to-order, Shine, Standardize and Sustain (as shown in Appendix I). The scoring technique developed by Ho (1999) in his audit tool considers an evaluation of a total number of non-conformance activities for a total score of 50. The ratings obtained from these questions indicate the success of a 5S event.

2.5 Kaizen Events

Kaizen in Japanese means of ‘change for the good’. It promotes positive changes in a small duration, which was first formulated by Deming for his work in Toyota in late 1960s (Bahensky et al., 2005). According to Melles (1994) the most important tools of Lean production are multifunctional task groups, simultaneous engineering and Kaizen. The Kaizen event begins with identifying the key process for which a process mapping is carried out by specifying the value and the non-value added activity for the customers (Womack et al., 2005). Kaizen philosophy enables the system for sharing ideas throughout the company hierarchy, encouraging employees to seek new opportunities and breaking down the barriers in information flow (Bahensky et al., 2005).

Kaizen does not focus on reorganizing the process to achieve incremental improvements, instead builds the quality in a process to enhance the continuous improvement (Bahensky et al., 2005). Functions of Kaizen spread in diverse fields, for instance in healthcare, the patient travel can be redesigned for an improved process which involves patient care in each step and every support process that goes through the value stream mapping (Jones et al., 2006).

Bahensky et al. (2005) emphasized that the Lean initiatives are implemented using the Kaizen Breakthrough Methodology, which uses Lean management approach to eliminate the non-value added processes relating it at the Takt time. Study conducted by Styhre (2001) aimed at incremental improvements of operations that make use of technology that creates a desirable outcome in operations and lower cost, individual work operations and personal development.

Jacobson et al. (2009) demonstrated a Kaizen program that provides a 24-hour day mechanism for continuous improvement with the help of Kaizen tracker in healthcare. The Kaizen tracker tracked the operations right from the employees by identifying the problem, reporting the issues to higher

authority, addressing the issue, implementing the changes and finally providing feedback to all stakeholder.

According to Bahensky et al. (2005), reduction of the lead time by the elimination of waste in the process is performed by the cross-functional teams who are guided by business improvement objectives which are a part of the Lean initiative adopted from the Kaizen breakthrough methodology. One of the major aspects of Kaizen breakthrough methodology is that it provides a systematic and an effective way of approaching a problem. It also provides ways for sustaining the performance thereby creating an environment for continuous improvement. This was witnessed in the study by Kanji (1996) who conducted a study to categorize the Plan-DO-Check-Act or the PDCA cycle into four stages of the implementation process (Figure 2.3).

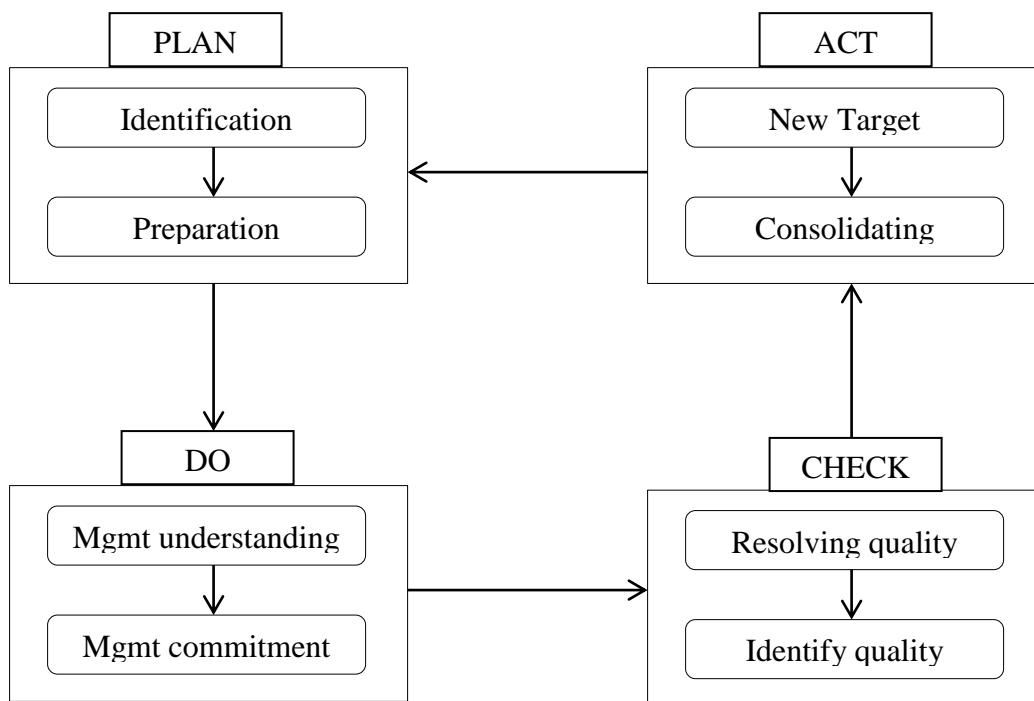


Figure 2.3. PDCA Model of Implementation [Adopted from Kanji (1996)]

Kaizen is least effective, as studied by Bahensky et al. (2005) shown, when many functional silos which need the cross-functional teams to breakdown the silo mentality for positive changes. He cautioned the use of Kaizen concept for changes in healthcare that can affect a patient's safety unless

there is a better understanding of the changes among the employees. He also states that the success of these events is dependent upon the organization's commitment and support to acknowledge the efforts of their employees.

2.6 Hybrid 5S Model- Background

Although several past studies have included ways of approaching Lean implementations, many papers have used various interpretations of this strategy in order to address an issue; this was found to be similar to each other in most cases. For example, Fine et al. (2009) stated a series of steps in Lean methodology, the first step defines the value, step two is to arrange by value stream, step three is flow, step four is pull value and step five is continuously seeking perfection. Zidel (2006) carried out a valuable tool for any improvement in a project called as Standardization of work which consists of seven steps, 1) document reality 2) identify the waste 3) land counter measure 4) implement changes 5) verify changes 6) quantify changes 7) standardize changes.

Fine et al. (2009) organized complex change efforts by composing a model. The model suggested that the “successful implementation of complex changes in a healthcare organization proceeded through these four stages” as shown in Figure 2.4.

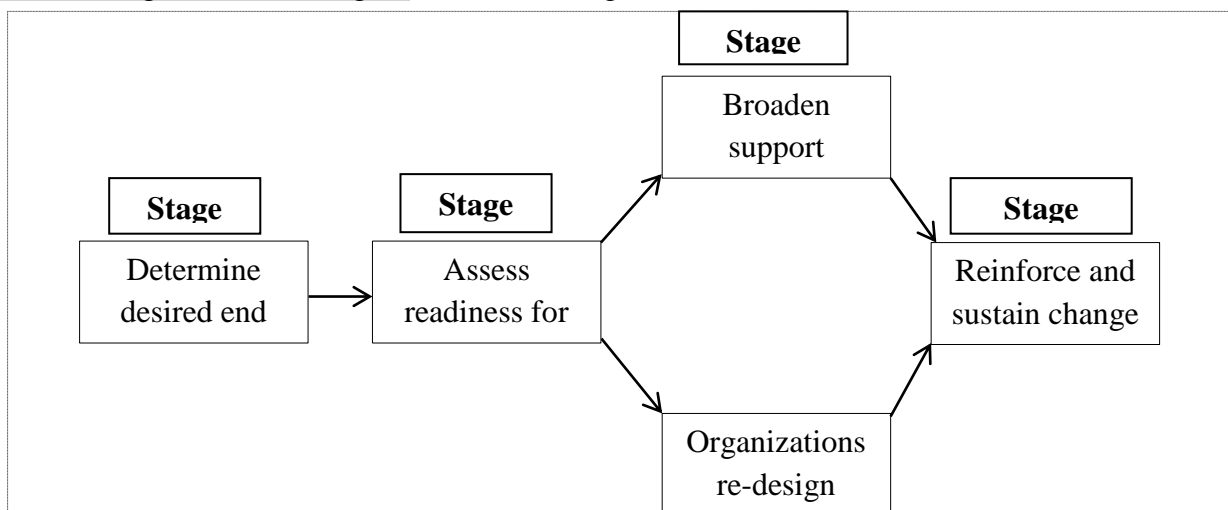


Figure 2.4. Four Stages of Leading Change [Adopted from Fine et al. (2009)]

Studies involving Kaizen events (discussed in section 2.4) also carried out a similar approach on conducting a project. This was done by classifying it into four phases of Kaizen events, which are based on the adoption of Deming's cycle or the PDCA cycle (Kanji, 1996).

The first phase is involved in observation and preparation based on which a plan is formulated (Wilson, 2000). Kim et al. (2006) described the first phase as documenting the actual phase where one goes to the work place and observes first-hand how the process operates. This helps to observe and understand the multiple areas of delay, inefficiencies and waste that may exist. Identification of a key process is determined initially in Kaizen by mapping the process and specifying the value to the customer's perspective (Womack et al., 2005). Understanding value as defined by the customers includes care that is of high quality, safe, efficient and appropriate (Kim et al., 2006).

Value Stream Mapping is an effective tool to identify opportunities for improvements and distinguish between the value added and non-value added activities (Kumar et al., 2006). Koning et al. (2006) emphasized the use of an extended process flowchart analytical tool called the value stream mapping. The value stream mapping not only helps in identifying the value added and non-value added activities but also provides information with speed along with continuity of flow, and work in progress (Koning et al., 2006). Kim et al. (2006) pointed out by working on the current state value stream map that the team members could identify specific areas of waste, delay, causes of error and inefficiency. This is a start for brainstorming ideas for improvement, proposing new ideas, eliminating wastes and transforming the process into value from the customer's perspective.

The second phase is planning for the Lean initiative that includes generating ideas with the team to design a new and a better process that is then depicted on the flow map using the future state value stream map Kim et al. (2006). For the current study, planning of the Lean initiatives involved inventory management techniques such as ABC classification, estimating ordering and carrying cost,

and layout re-design. ABC classification is being used in the manufacturing firms but would also be appropriate for pharmaceutical due to its need for a classification scheme of medicines (Minifie et al., 1987). Another aspect of the Lean initiative in the planning phase is the redesign strategy. According to King et al. (2006), redesigning strategy helps to improve the process flow in a healthcare perspective.

The third phase (implementation) deals with the establishment of 5S, a process improvement tool for organizing the warehouse operations. 5S is a systematic Lean tool and the simplest to implement for organizing and standardizing the workplace (Kilpatrick, 2003).

Finally, the fourth phase measures the improved process that consists of evaluation based on process, effectiveness, efficiency, relevance and impact (Wilson, 2000). Fine et al. (2009) pointed out that sustaining a Lean initiative is the most challenging phase and needs to be addressed by treating it as a long-term commitment. To ensure the effectiveness of the Hybrid 5S model performance metrics such as 5S audit tool developed by Ho (1999) is utilized. Also, in order to determine the impact on the inventory of the warehouse, inventory turnover can be assessed.

Based on this extensive study, a Hybrid 5S model was developed (as shown in Figure 2.5) which establishes four phases of Kaizen events by integrating the process improvement tools with the inventory management techniques.

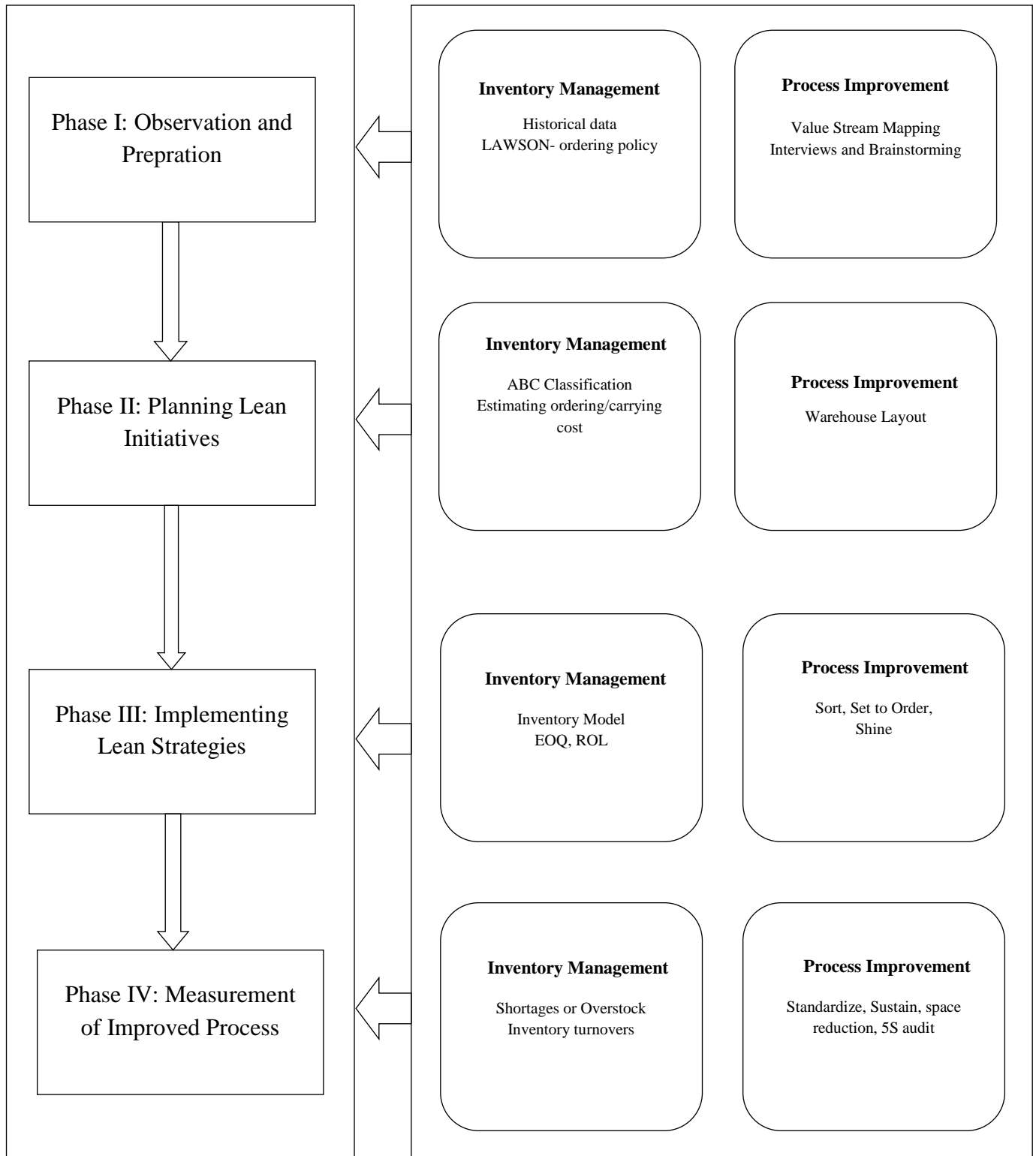


Figure 2.5. Hybrid 5S Model

CHAPTER 3: RESEARCH METHODOLOGY

The purpose of this research was to explore and identify an effective approach to implement the Lean tool 5S that will improve hospital warehouses operations. The goals were to improve the inventory turnover using the inventory management techniques and organize the supplies to optimize the usage of warehouse space using process improvement tools.

3.1 Objectives

1. To implement, document and evaluate the impact of implementing a Hybrid 5S strategy (integration of inventory management techniques and process improvement tools) versus two Traditional 5S on hospital warehouses' operations.

2. To develop guidelines for an effective implementation of Lean strategies for warehouses' operations in the healthcare industry.

3.2 Research Scope

The scope of the research was to showcase the application of Lean strategies to improve warehouses' operations in a healthcare organization. In particular, this research focused in a key Lean tool, the 5S. The current study was carried out in Ochsner health system that possesses 8 hospitals and 35 clinics in the state of Louisiana. However, the area of research was concentrated in the warehouses of 3 hospitals (Baton Rouge, Kenner, and Baptist) holding similar supplies and operations.

3.3 Research Questions

The research questions involved in this study were:

- 1) Did the Lean strategies influence the inventory of the warehouses'?
- 2) Is the Hybrid 5S strategy better than the Traditional 5S?

Question 1 analyzed the impacts of Lean methodology before and after the implementation at the three hospital warehouses. This study analyzed the outcome of inventory turnover before and after the implementation of Lean strategies by checking for the existence of any significant difference due to the

improvements implemented.

Question 2 evaluated the best practice between the two 5S strategies by comparing each other with its outcome based on a 5S audit tool tailored from Ho's 5S audit tool (Ho, 1999). A set of implementation guidelines were developed based on the audit results. The guidelines list the steps for an effective implementation of the best 5S strategy for healthcare warehouses.

3.4 Research Methodology Flowchart

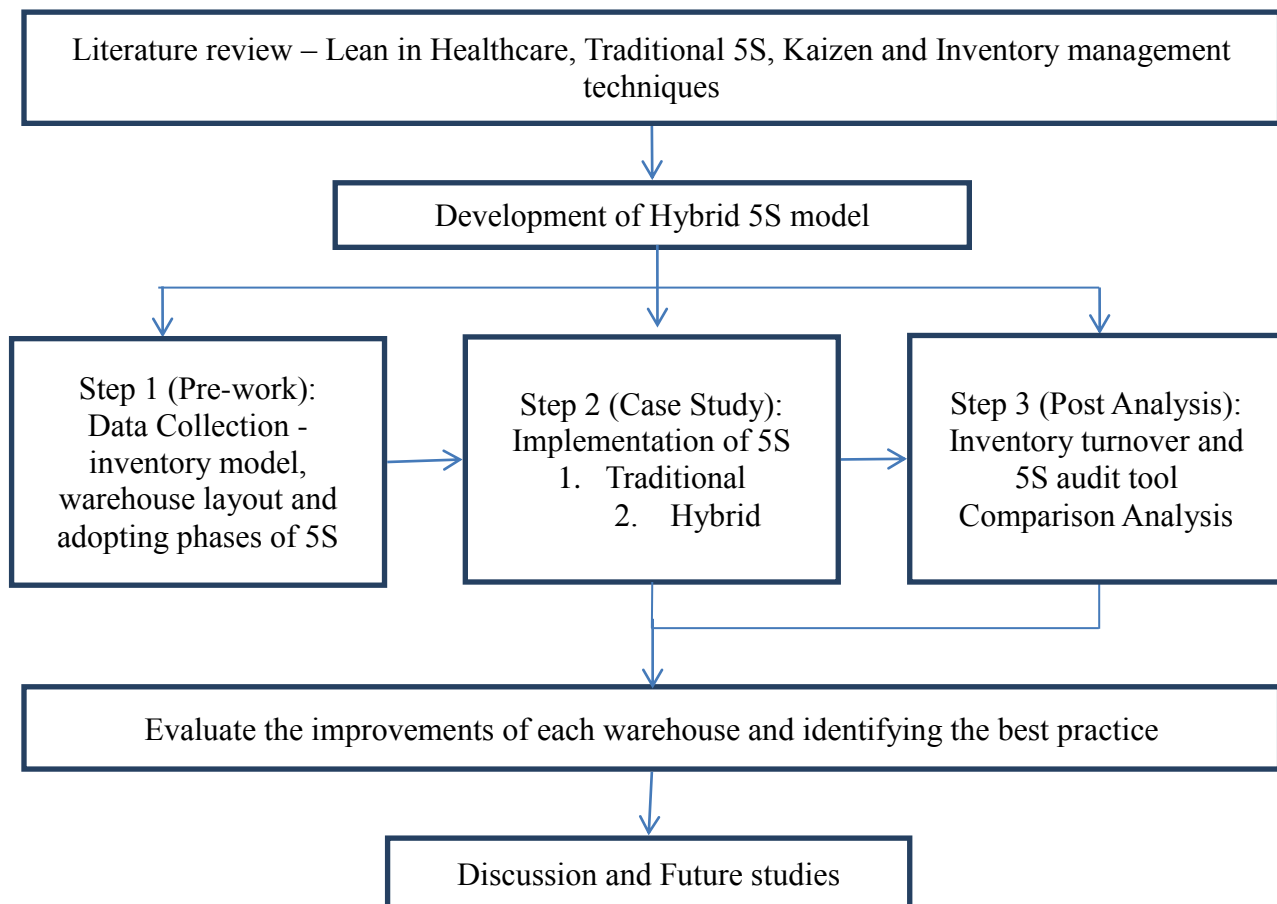


Figure 3.1. Research Methodology Flowchart

3.5 Theoretical Foundation

Table 3.1. Theoretical Foundation

Authors (Year)	Process Improvement Tools and Inventory Techniques	Research Purpose	Findings
Koning et al. (2006); Kim et al. (2006); Jimmerson et al. (2005); Graban (2008)	Lean in Healthcare	Lean implementation in healthcare	Shorter length of stay, Standardization of process, reduced confusion and rework.
Zidel (2006); Ho (1999); Pheng and Khoo (2001)	Traditional 5S practices	5S stages, audit tool, problem identification and solutions.	Lean tools-reduce non-value added activities. Identify non-conformance in organization.
Jacobson et al. (2009); Bahensky et al. (2005); Kanji (1996)	KAIZEN approach	Determine a systematic approach for problem solving	Increase quality in process and enhance continuous improvement
Kumar et al. (2006); Kelle et al. (2009); Guvenir and Erel (1998)	Inventory Techniques-ABC classification, Inventory control in healthcare	Importance of inventory management tools and techniques	Control in ordering procedures, effective classification of supplies and reduced inventory and carrying costs

3.6 5S Implementation

The data collection consists of acquiring data for pre-work and post analysis of the Kaizen event for the three hospital warehouses'. Since the hospitals followed different Lean strategies, the data collection process is distinctive for the Traditional and Hybrid 5S, therefore, explained separately.

3.6.1 Hybrid 5S

Ochsner Health System, Baton Rouge Central Supply, was chosen for the study to implement the Hybrid 5S. This implementation was carried out for a period of 4 months with 15 warehouse workers including the director and a Lean leader. Their current practice for inventory management was driven by the experience of one single employee. The warehouse was facing problems such as 1) Over/under stocked supplies, 2) Increase in time due to look-up of supplies, 3) Space constraints, 4) No standardized process in the arrangement of supplies. To address these problems, the Hybrid 5S model was implemented (Section 2.5). The Hybrid 5S was carried out in four phases, with the objective of standardizing supply chain processes and optimizing warehouse operations.

Pre-work (First Phase) entailed planning and preparation of the Lean initiatives to understand the current process which was carried out by conducting a brainstorming session with the materials management director, Lean leader, and a Lean intern. The outcome of this effort was a draft of the current state value stream map (as shown in figure 3.2) of the warehouse operations.

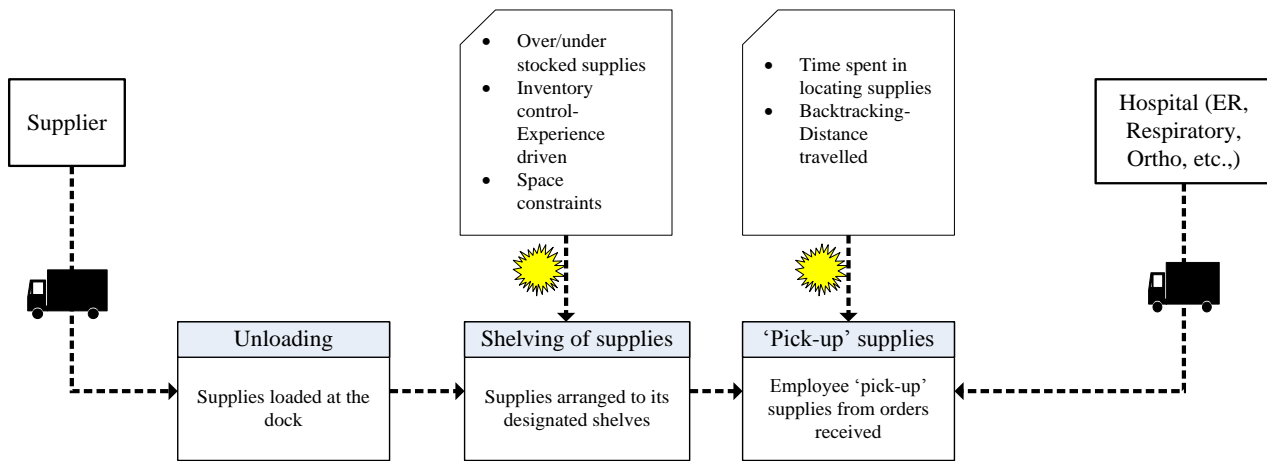


Figure 3.2. Current State Value Stream Map (Hybrid 5S)

The planning included assessing their current inventory, space utilization and the distance travelled by the employees. Spaghetti maps were used to determine distance travelled for picking various clinic and department's orders. For instance, the travel pattern for picking up supplies for

Telemetry department in the hospital is shown in figure 3.3 below. Bottlenecks were observed during the daily routine of picking orders resulting in excess travel for the warehouse personnel, thus increasing the pick-up time of each order.

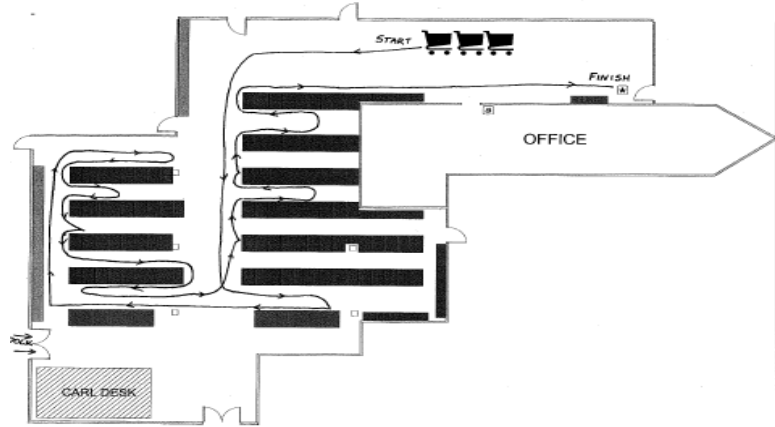


Figure 3.3. Spaghetti Map (Example: Travel pattern-Supplies for Telemetry)

The pre-work witnessed inaccuracies in determining re-order levels and order quantities. This resulted in excess inventory, which in turn lead to, more space being occupied.

Second Phase involved carrying out the Lean program by adopting the inventory management tool, ABC, inventory model and re-designing the layout of the warehouse. ABC classification categorizes the most critical supplies as ‘A’, moderate supplies as ‘B’ and least effective supplies as ‘C’ category. ABC classification is based on the inventory value of each supply that is a product of annualized sales and the unit cost. The supplies are arranged in descending order and later classified as ‘A’, ‘B’, or ‘C’.

To develop a deterministic inventory model, the ordering cost and the holding cost are primarily estimated to establish the Economic Order Quantity (EOQ) and Re-Order Level (ROL) that is then updated into the LAWSON. The basic inventory model for calculating EOQ and ROL are as follows:

$$EOQ = \sqrt{2AD/H}$$

Equation (1)

Where,

A = Ordering Cost,

D = Annualized Demand,

H = Holding Cost.

The Reorder Level (ROL) is expressed as;

$$\text{ROL} = \text{Lead time (L)} * \text{Demand (D)} / 365 \quad \text{Equation (2)}$$

Equation (1) represents a deterministic inventory model, which assumes that a uniform demand exists throughout the cycle. However, healthcare operations are subjected to uncertain demand; therefore, there is the need to incorporate probabilistic models in the calculations of LAWSON. Currently, LAWSON supports the use of EOQ and ROL as expressed in equations (1) and (2). The ordering cost (costs incurred right from ordering to receiving the goods) is determined through by summing up costs incurred right from ordering to receiving the cost analysis. Benchmarking was used as a substitute for inaccessible information. Therefore, results from the Association for Healthcare Resource & Materials Management (www.ahrmm.org) were used to determine the holding costs of each supply in the hospital warehouse. Another important aspect of the implementation process of the Hybrid 5S model was the redesign of the layout. Various sessions of brainstorming and interviews were conducted among 10 employees, who were involved in redesigning the warehouse layout and allocating supplies to their designated shelves.

The redesigned layout focused on reducing the distance travelled by employees for picking supplies. This was made possible by classification of the supplies based on results from the ABC classification that limits the frequency of employee travel to 'A' and 'B' class supplies. The supplies

were classified based on the results of ABC classification with the idea of restricting employee travel to 'A' and 'B' class supplies.

Implementation (Third Phase) includes the implementation of the inventory model and the five steps of 5S which is sort, set to order, and shine.

Post-Analysis (fourth phase) is the performance measurement of the hospital warehouse by evaluating its monthly inventory turnovers and determining the effectiveness of 5S using an audit too.

3.6.2 Traditional 5S

To study the impact of Ochsner's Traditional 5S, the implementation was carried out in two central warehouses at Ochsner Health System – Baptist and Kenner facilities. The Ochsner's Traditional 5S comprised three phases: 1) Pre-work, 2) Actual implementation, and 3) Post analysis.

Pre-work addresses inventory (e.g. manually adjusting on-hand quantities to reflect true demand), tools/equipment required, planning resources, and considering visual and ergonomic enhancement techniques through various brainstorming and interview sessions. The time spent and the distance travelled in searching for supplies is assessed using Spaghetti maps.

Implementations of the 5S events such as sort, set-to-order, shine, standardize and sustain were performed in this phase.

Post-Analysis (fourth phase) is the measurement of the performance of the hospital warehouse by evaluating its monthly inventory turnovers and determining the effectiveness of 5S using an audit tool which rates each warehouse based on the number of non-conformities.

3.6.3 Comparison Analysis

After data collection and documentation of the Hybrid and Traditional 5S implementations, results were evaluated to assess the impact of the 5S strategies implemented at hospital warehouses. A Hypothesis is structured for data analysis of the inventory turnovers results obtained before and after

the implementation of the 5S strategies. Inventory turnover for a year was considered with 6 months before and after the implementation of the Traditional 5S method implemented in Kenner and Baptist hospital warehouses. In case of the Baton Rouge hospital warehouse, inventory turnover over for a period of 22 months was evaluated with 11 months before and after the implementation of the Hybrid 5S strategy. Inventory turnover is the ratio of the cost of goods sold to the average inventory. For the hypothesis testing, the data of the inventory turnover of each month were recorded and analyzed to determine statistically significant change in the inventory turnover before and after implementation of the 5S strategy using ANOVA with an $\alpha = 0.05$. If a significant change is detected statistically, it implies that there is an improvement in the inventory turnover after the implementation of the 5S program. Significant change indicates an increase in inventory turnover after implementation.

Null Hypothesis H_0 : There is no significant change in the inventory turnover for the warehouse after the implementation of Lean strategy. Alternative Hypothesis H_1 : There is a significant change in inventory turnover for the warehouses after the implementation of Lean strategy.

This study aims in evaluating the best practice of 5S in hospital's warehouse operations. The null hypothesis states that there is no change in the inventory turnover, in the warehouse, after implementation evaluating the magnitude of inventory turnover, whereas alternative hypothesis proposes the existence of a significant increase in inventory turnover. Significant difference in the inventory turnovers was determined using ANOVA in Statistical Analysis Software version 9.2 for each of the three warehouses.

3.7 5S Audit

In order to assess the effectiveness of the warehouse, six months after the implementation of both 5S models, Lean professionals, who actively participated in the process improvement initiatives for the three warehouses, conducted the audit. This was done six months after the implementation of

both 5S models. The 5S audit is based on the adoption of Ho (1999) who identified non-conformities as a setback for auditing a 5S implementation. The 5S audit (as shown in Appendix 1) was tailored to hospitals warehouse operations. The ranking ranges were as following: 0-5 non5 non-conformities were ranked as ‘excellent’, 6-10 non-conformities were ranked as ‘good’, 11-15 non-conformities were ranked as ‘average’, 16-20 non-conformities were ranked as ‘marginal, and non-conformities greater than 20 were ranked as ‘poor’. Finally, the scores were compared among participating hospitals and a 5S scorecard comparison matrix was designed to record the overall scores.

3.8 Development of Guidelines for a Successful Implementation of Lean in Healthcare Warehouse Operations

A set of implementation guidelines was developed based on the results of the best Lean practice among the Hybrid and Traditional 5S models. These guidelines will serve as a template to implement Lean strategies to effectively organize and manage hospital warehouse supplies. The structure of the guidelines will begin from each phase of the Hybrid 5S event and finally provides performance metrics that can be used to assess the status of the warehouse.

CHAPTER 4: RESULTS

The data analysis was done, and the results generated according to the research methodology, in three steps, including results from Pre-work, Implementation and Post Analysis step.

4.1 Step 1 (Pre-work)

Results from the Hybrid 5S model implementation, during the pre-work (Phase 1 and Phase 2), revealed inaccuracies in determining re-order levels and order quantities resulting in excess inventory, which led to more space being occupied. Also, bottlenecks were observed during the daily routine of picking orders, which caused excessive travel for the warehouse personnel, thus, increasing the picking time of each purchase order. The initial observations and planning was carried out for a period of 4 months by a team consisting of the Lean manager, Lean intern and Baton Rouge Materials Management Director.

Outcome of the ABC classification showed that nearly 53% of the overall supplies (i.e.149 out of a total of 1100 supplies) in the A-category, constituted 82% of the total inventory value, as shown in figure 4.1.

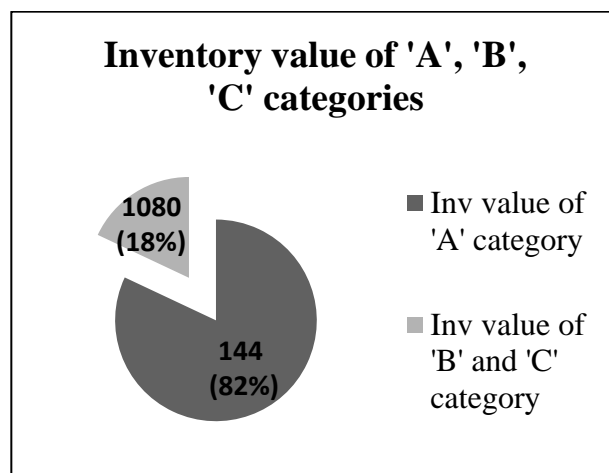


Figure 4.1. ABC Classification

The calculated EOQ and ROL revealed a decrease in order quantities and re-order levels in most cases. The layout redesign witnessed a straight-line pattern of the arrangement of racks starting

with the 'A' category supplies followed by 'B' and 'C' categories as shown in figure 4.2.

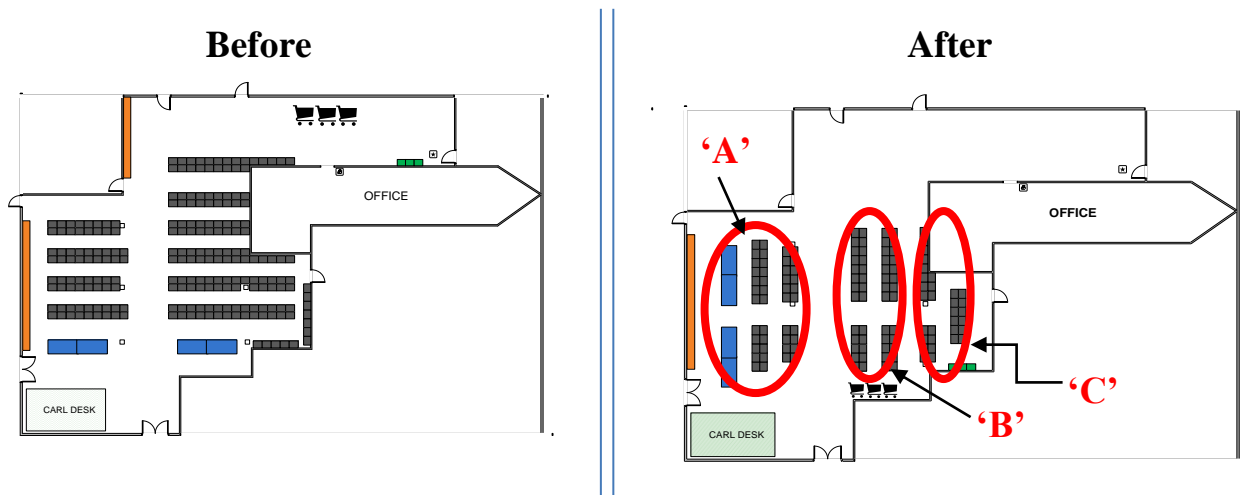


Figure 4.2. Warehouse Layout Redesign Strategy

In the case of Traditional 5S implementation, the observations were carried out in Kenner and Baptist Hospital warehouses by a team of Lean professionals led by a Lean manager and two Lean interns, for a period of 1 month. Measures were not taken to redesign the overall layout of the warehouses. Issues with the current system were that they failed to address the distance travelled by employees for picking up supplies. The supplies were grouped based on functional aspects rather than frequency of usage.

By mapping out the current process, we were able to conclude that the main issue was the lack of proper inventory control measures in the three warehouses, therefore, addressing the research question 1. Counter measures had to be deployed for all the warehouses individually as carried out in Step 2.

4.2 Step 2 (Implementation of 5S)

In the case of the Hybrid 5S implementation, the counter measure involved the adoption of an inventory model. The Traditional 5S implementations involved the manual adjustment of on-hand quantities of each stored supply.

For both 5S models, the implementation was carried out for a period of two days, on a weekend. Roles and responsibilities were assigned to the stakeholders who were asked to carry out each stage of the 5S, without disturbing their day-to-day activity.

In the case, of the Hybrid 5S model, the implementation of “sort” resulted in removal of obsolete supplies and a space reduction of 15.7%. In the “Set to Order” step, participants labeled each supply and aisles following the ABC classification. The racks were rearranged and placed to their designated area, based on the results from the spaghetti diagram. Space was allocated for each supply based on the formula - 75% of the sum of its EOQ and ROL values. Shelf and rack height were standardized following OSHA (Occupational Safety and Health Administration) guidelines. “Shine” entailed cleaning the floors and aisles from oil and dust, cleaning the racks and providing sufficient lighting to each aisle. “Standardize” included the adoption of a reorder report, at the end of each day, by warehouse employees using the LAWSON software. Visual management techniques were introduced to alert supplies exceeding the space allocated. A 30-day action plan was formulated to “sustain” the improvements, which included a periodical check on category ‘A’ supplies.

In the implementation of “sort” for the Traditional 5S model, the first phase of 5S included the plan to eliminate obsolete supplies based on the usage report. These supplies were red tagged for removal from the central warehouse. However, reduction in space was not observed by assessing the warehouse layout before and after the 5S implementation. “Set to Order” entailed grouping similar supplies and labeling of supplies and aisles. Measures were taken to ensure each supply had a unique

location within the warehouse. A cleaning policy was enforced to monitor the tidiness of the warehouse. An audit plan was created for to ensure “sustain” and “standardize” improvements.

Table 4.1. Summary of the Implementation of the Traditional and Hybrid 5S Events

5S Steps	Ochsner’s Traditional 5S	Hybrid 5S
Pre Work	<ul style="list-style-type: none"> ✓ Circles of Work ✓ Experience driven inventory management 	<ul style="list-style-type: none"> ✓ Spaghetti Map ✓ Circles of Work ✓ Redesign Strategy ✓ Historical usage driven Inventory Model
Sort	<ul style="list-style-type: none"> ✓ Removed obsolete or rarely used supplies 	<ul style="list-style-type: none"> ✓ Remove trash and obsolete items
Set-to-Order	<ul style="list-style-type: none"> ✓ Visual Enhancement ✓ Ergonomic Enhancement ✓ Grouped like items together ✓ Created signage to clearly label items and aisles ✓ Created new catalogue to increase ease of access for end users ✓ Consolidated locations to ensure each supply has only 1 designated storage space 	<ul style="list-style-type: none"> ✓ Grouping of supplies based on ABC classification ✓ Analyze space requirement for supplies ✓ Placing the racks to its designated area ✓ Assign and label items to its new location ✓ Label ‘A’ category items on each rack or shelf ✓ Clear representation of each aisle
Shine	<ul style="list-style-type: none"> ✓ Created a cleaning mechanism 	<ul style="list-style-type: none"> ✓ Floors and passage ways free from oil or dust. ✓ Cleaning the racks. ✓ Providing sufficient lighting.
Standardize	<ul style="list-style-type: none"> ✓ Standard work document which states the problem, action taken and its results 	<ul style="list-style-type: none"> ✓ LAWSON- Reorder report end of every day ✓ Reorder quantities based on inventory model ✓ Visual Management of supplies exceeding the space allocated
Sustain	<ul style="list-style-type: none"> ✓ 30 day action plan to sustain 	<ul style="list-style-type: none"> ✓ Period check on ‘A’ category materials ✓ 30 day action plan to sustain

A 30-day action plan was developed for sustaining the improvements of the warehouse, which includes the issues encountered, actions taken, and the status of its completion. The implementation step focused on identifying the better of the two 5S strategies with the help of the audit tool. The actual implementation of 5S is done in this step, therefore, answering the research question 2. This is shown for every phase individually in table 4.1.

4.3 Step 3 (Post-Analysis)

The data used for the hypothesis testing included monthly inventory turnover and the 5S audit scores obtained from the three participating hospital warehouses. The inventory turnovers were obtained from the LAWSON software based on historical usage data.

In order to evaluate the hypothesis, ANOVA was used for the Hybrid and Traditional 5S models, which was implemented in the three hospital warehouses (Baton Rouge, Baptist and Kenner). Figure 4.3 indicates the monthly inventory turnovers before and after the implementation of Traditional 5S models for each month in the two hospitals. In the case of Traditional 5S, the calculation of the inventory turnover was done over a period of 12 months (6 months before and 6 months after implementation).

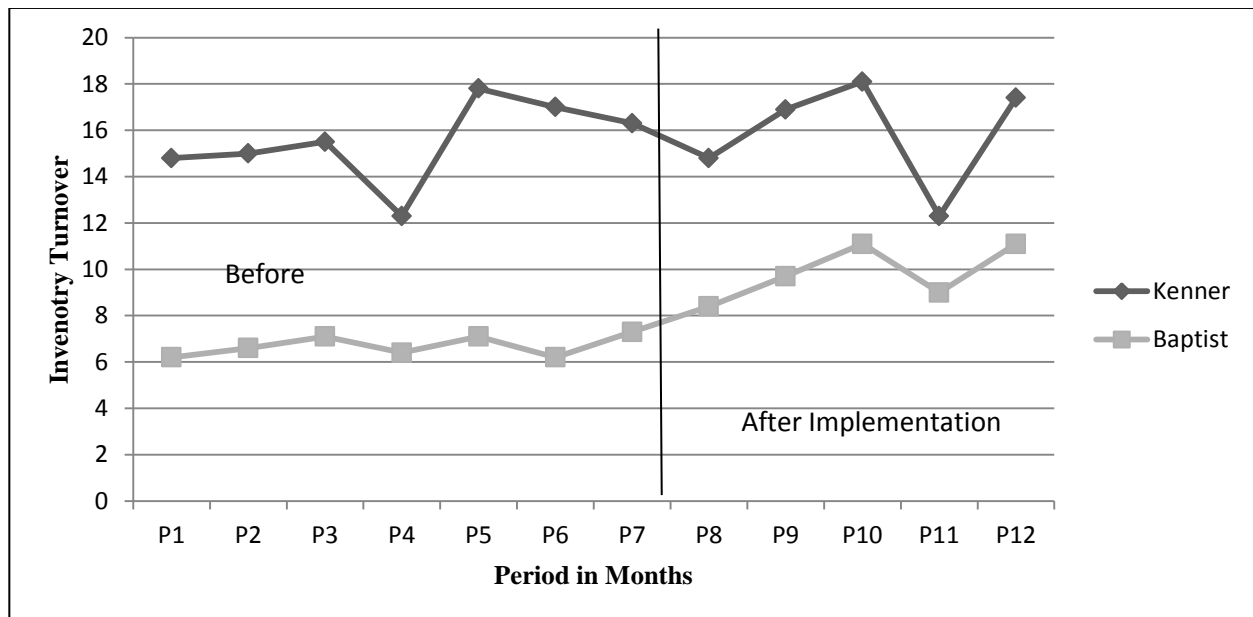


Figure 4.3. Inventory Turnover Before and After Implementation of Traditional 5S Model

The inventory turnover was calculated over a period of 22 months for the Hybrid 5S model (11 months before and 11 months after implementation). Figure 4.4 indicates the inventory turnover before and after the implementation of Hybrid 5S model for each month in one hospital.

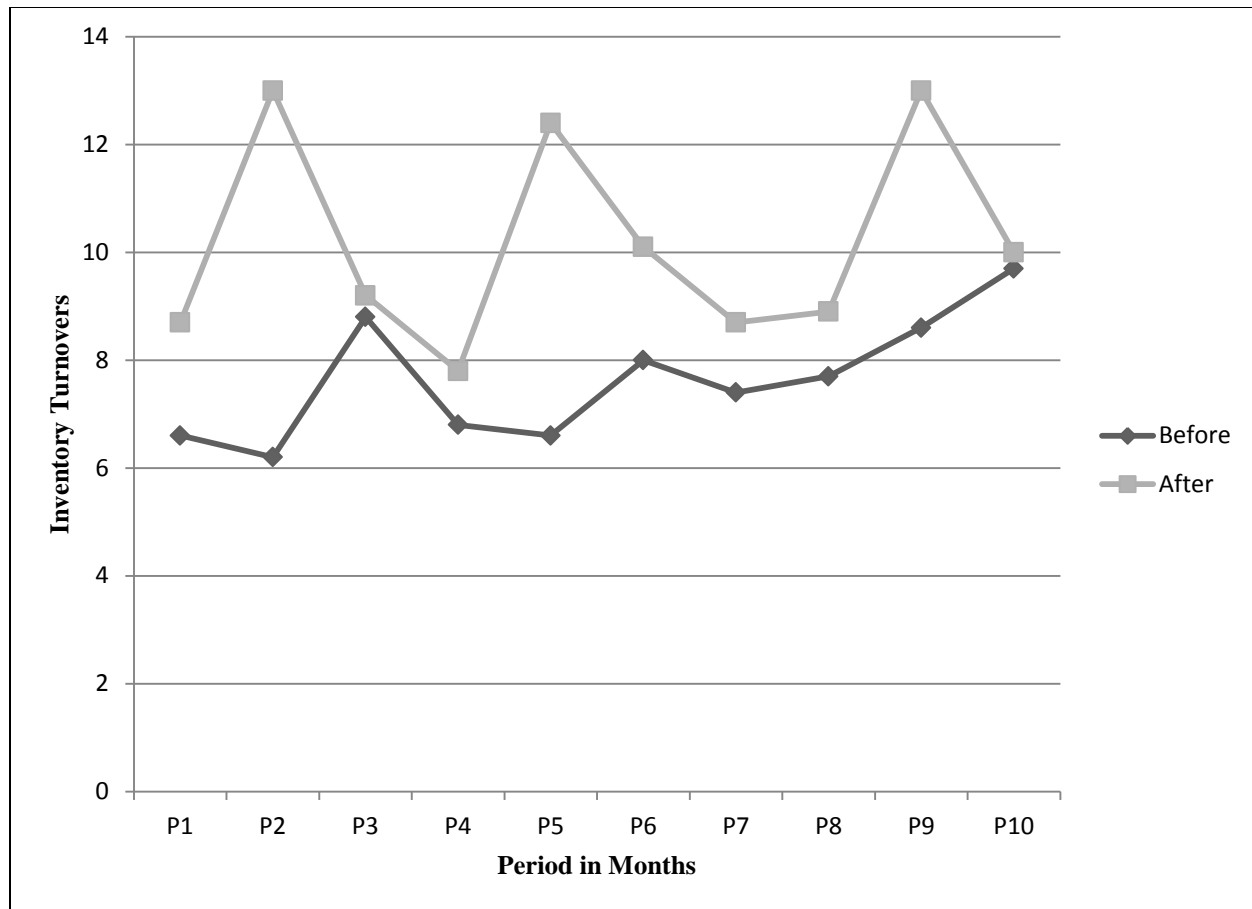


Figure 4.4. Inventory Turnover Before and After Implementation of Hybrid 5S Model

A one-way analysis of variance was performed to determine the effects of the independent variables (before and after implementation) on the dependent variable (inventory turnovers) for Hybrid 5S model implemented in Baton Rouge Hospital. The ANOVA model in table 4.2 describes the statistical method used for evaluation with $\alpha=0.05$ level of significance. The null hypothesis H1 states that there is no significant difference between the inventory turnover values before and after the implementation of the Hybrid 5S model in Baton Rouge Hospital. The alternate hypothesis H2 states that there is a significant difference between the inventory turnover values before and after the implementation.

Table 4.2. Analysis of Variance Results for Hypothesis - Hybrid 5S in Baton Rouge Hospital

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	29.85895000	29.85895000	12.40	0.0021
Error	20	48.16950909	2.40847545		
Corrected Total	21	78.02845909			

The p value of the model was 0.0021, which is less than the significant level of 0.05; therefore, the null hypothesis was rejected, as there was no significant difference between the values of inventory turnover before and after the implementation of Hybrid 5S model. We concluded that there was a statistically significant change in inventory turnover before and after implementation.

The ANOVA model performed for the Traditional 5S – Baptist facility is shown in table 4.3 below.

Table 4.3. Analysis of Variance Results for Hypothesis - Traditional 5S in Baptist

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	24.08333333	24.08333333	19.59	0.0013
Error	10	12.29333333	1.22933333		
Corrected Total	11	36.37666667			

The p value of the model was 0.0013, which is less than the significant level of 0.05; therefore, the null hypothesis was rejected, as there was no significant difference between the values of inventory turnover before and after the implementation of Hybrid 5S model. We concluded that there was a statistically significant change in inventory turnover before and after implementation of Traditional 5S model in Baptist facility.

The ANOVA model performed for the Traditional 5S – Baptist facility is shown in table 4.4 below.

Table 4.4. Analysis of Variance Results for Hypothesis - Traditional 5S in Kenner

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.96333333	0.96333333	0.24	0.6377
Error	10	40.85333333	4.08533333		
Corrected Total	11	41.81666667			

The p value of the model was 0.6377, which is greater than the significant level of 0.05; therefore, we fail to reject the null hypothesis that there is no significant difference between the values of inventory turnover before and after the implementation of Hybrid 5S model. We conclude that there is no statistically significant change in inventory turnover before and after implementation of Traditional 5S model in Kenner facility.

In order to assess the effectiveness of the warehouse after 6 months of implementation of both 5S models, an audit was conducted among an expert team consisting of three Lean professionals. The 5S audit was modified to suit hospital warehouses, where a score range of 0-5 non-conformities were depicted as ‘excellent’, 6-10 as ‘good’, 11-15 as ‘average’, 16-20 as ‘marginal’, and greater than 20 was depicted as ‘poor’ implementation. Finally, the scores were compared among results from all three hospitals and a 5S audit comparison matrix was developed to display the overall scores for each stage of the 5S as shown in the table 4.5.

Table 4.5. 5S Audit Comparison Matrix

	Sort	Set to Order	Shine	Standardize	Sustain	Overall non-conformities
Warehouse 1 (Baton Rouge)	1	2	2	3	1	9
Warehouse 2 (Baptist)	2	1	3	6	4	16
Warehouse 3 (Kenner)	2	2	3	6	5	18

CHAPTER 5: CONCLUSION AND DISCUSSION

5.1 Conclusion

By mapping out the current process, we were able to conclude that the main issue was the lack of proper inventory control measure in the three warehouses. In order to answer research question 1 hypothesis was stated to determine whether there was a statistical significant difference in the inventory turnover after the introduction of Lean. Results proved that there was an influence in the inventory turnover for the Lean strategies. The implementation step focused on identifying the better of the two 5S strategies with the help of the audit tool. The audit tool was selected in order to answer research question 2 that evaluates the effectiveness of the Hybrid 5S. From the results of the 5S audit, it was clearly seen that the warehouse that implemented Hybrid 5S witnessed the least number of non-conformities making it a better than the Traditional 5S

5.2 Discussion

In the case of the Hybrid 5S, the Pre-work was very comprehensive when compared to the Traditional 5S model. For instance, adoption of ABC classification in Hybrid 5S resulted in identifying 149 supplies that constituted about 82% of the overall inventory. Therefore, special emphasis was given to these 149 supplies classified in category 'A' by utilizing techniques such as visual management, inventory control and layout redesign. These processes were neglected in Traditional 5S due to which the causes of the inefficiencies were not identified. This resulted in poor layout design, ineffective inventory control techniques and more space being occupied.

The Hybrid 5S implementation resulted in saving 15.7% of the space by reducing the number of steel racks from 171 to 149. Warehouse space reduction was not observed for either Traditional 5S case. Martinennly (2008) discussed that hospitals in most cases are constrained due to lack of space forcing them to order less. The ABC classification of supplies and the rearrangement of the aisles in Hybrid 5S resulted in reduced travel distance for pick-up. This was not the case with Traditional 5S,

where the supplies were grouped based on their functionality (e.g. supplies related to Ophthalmology, Emergency, Rheumatology, Gynecology etc.). Clear labeling of supplies was done for both the 5S strategies, although, Hybrid 5S labeling involved unique tags for Category 'A' supplies.

Results from the hypothesis test showed no significant difference with regard to monthly inventory turns, for Kenner warehouse facility before and after the implementation of Ochsner's Traditional 5S model. SAS output showed a statistically significant change, before and after implementation, for the Hybrid 5S in the Baton Rouge warehouse facility due to the incorporation of inventory control tactics. Inventory turns of the facility showed a greater level of improvement immediately after the implementation of Hybrid 5S with an increase of 59.5% compared to the Traditional 5S at 15% and -4.1%. One of the Traditional 5S implementations witnessed an increase in inventory turnover (15%), due to the manual adjustment of the on-hand quantities but decreased in the other facility (-4.1%). Similar to Marinennly (2008) findings, all three case studies the ordering was usually experience-based or politically driven leading to overstocking some of the supplies. Hence, this research found high levels of inventory prior to the implementation of the 5S.

The results from 5S comparison matrix reflected a marginal rating for Ochsner's Traditional 5S with scores of 16 and 18. The Hybrid 5S produced 9 non-conformities making it a 'good' rating. After implementation Hybrid 5S showed a positive influence on the warehouse with an increase in inventory turnover of 59.5% and least rating for non-conformities of 9. This may be due to the incorporation of Kaizen, which provided a means to identify the causes and provided a systematic procedure. In contrast, Traditional 5S neglected the actual problem and focused on temporary benefits rather than permanent solutions. Moreover, the Traditional 5S ignored the use of inventory techniques and other Lean process improvement tools best suited for the facility. Other factors that influenced the Hybrid 5S was team work and employee and management's commitment. As mentioned by Pheng and Khoo

(2001), for a self-sustained progress in a process, employees should be encouraged to identify and provide solutions for a problem.

The results of the study show that Hybrid 5S had the greatest impact compared to Traditional 5S. When we consider the research question one, based on the results from all the steps we can conclude that there was a marked increase in inventory turnover after the implementation in two warehouse facilities, Baptist and Baton Rouge. The 5S audit tool facilitated the identification of the best 5S strategy among the two, which was found to be the Hybrid 5S technique. Tasks such as “Straight line or right angled arrangement of shelf”, “Usage frequency-based for supplies” and “One stop service for customer” was mainly due to the redesign strategy and ABC classification. It was concluded that the Hybrid 5S strategy with the least number of non-conformities is more effective than the Traditional 5S strategy, therefore, answering the second research question that Hybrid 5S is better than Traditional 5S technique.

However, it was observed that some of the tasks were non-conformity for all the three hospitals. For instance, the task “One location for each item” in “Sort” was unfulfilled in all the three hospitals. “Set-to-Order” witnessed that the task on “30-second retrieval of supplies” was unfulfilled. In “Shine”, “Regular sparkling and cleaning campaigns” and “Clean even the places most people do not notice” was unfulfilled. It was observed that most of the non-conformities were detected in “Standardize”. Tasks such as “Monitoring and updating inventory frequently”, “Constant education of training for employees on best practices” and “Constant improvement in inventory turnovers” were unfulfilled by the three hospital warehouses. In “Sustain”, “Education and training on 5S practices” remained to be a concern.

5.3 Guidelines for a Successful Implementation of Lean in Healthcare Warehouse Operations

A set of guidelines is formulated based on the success of the Hybrid 5S strategy that can be

replicated in other hospital warehouses (as shown in Appendix 2). The guidelines begin with pre-work where techniques such as value stream mapping, 5-Whys, fish bone, Circle of work, interviews and brainstorming sessions to understand the current process and identify the cause. The next phase involves planning and problem-solving methods to approach a problem. ABC classification, inventory control techniques and layout redesign can be used as a good start. The implementation should include the stages of 5S such that they conform to the standards as set by Ho (1999) in his audit tool. The performance metrics such as distance, time, cost, or space, should be defined in the beginning. Evaluation of the implementation should be measured using standard scorecards or audit tools as the one mentioned in this study.

5.4 Future Research

An effective method such as regular team huddles and education to the employee needs to be carried out for sustaining the improvements in the future. This was well observed after the implementation in Step 2, where inventory turnover showed non-uniform distribution rather than a steady increase for all the three warehouses (Figure. 5.1). Employee training and top-management involvement need to be exercised constantly for a successful implementation of a Lean initiative. Future studies can include the influence of employee cooperation in analyzing the performance of a Lean project. Hybrid 5S can be improved by incorporating various other Lean tools and techniques such as mistake proofing, automation and Just-in-time.

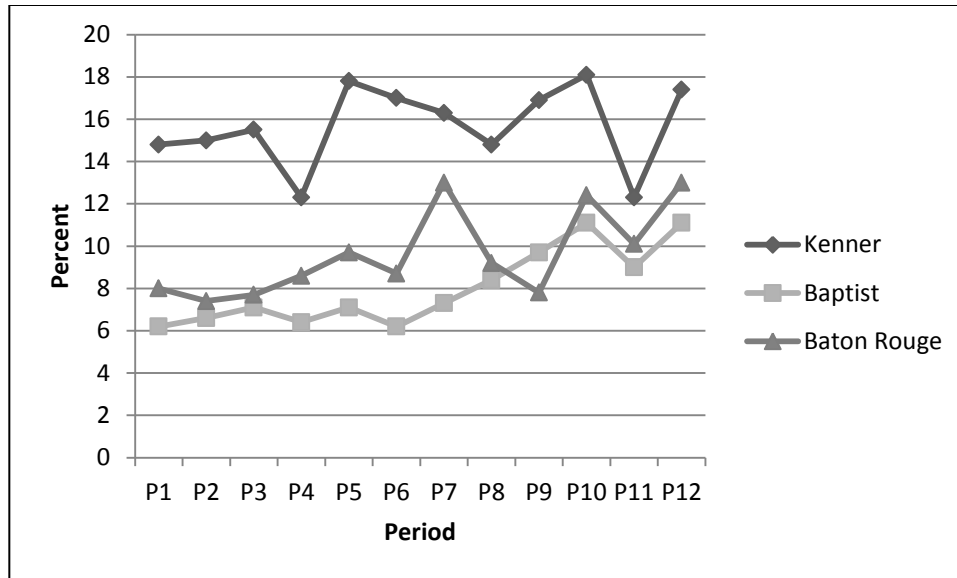


Figure 5.1. Comparison of Inventory Turnovers Over 12-Month Period

As Kelle et al. (2009) emphasized in their study, the actual demand is difficult to be determined in healthcare. Hence, probabilistic models will be more beneficial for inventory management that can satisfy uncertain or seasonal demand in healthcare. The influence of the number of beds in a hospital facility was not considered which could have affected the inventory turnover. Seasonal demand of supplies during natural or anthropogenic calamities was not considered for which forecasting techniques could be adopted. These issues ought to be addressed in order to overcome the limitations in this research. The inventory turnover was not normalized with respect to the number of patients due to unavailability of data. The normalized data could be helpful in comparing the inventory turnover between the warehouses rather than just determining the influence of Lean before and after its implementation. Some of the possible confounding factors that were not addressed in the 5S Audit survey include the differences between the raters who audited the warehouse and influence due to the lack of employee cooperation and adaptability can be studied.

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APPENDIX 1: 5S AUDIT-TAILORED FROM HO (1999)

Hospital Audited:

Date:

Note: If a checkpoint is not applicable, write down N/A. Some of the "typical activities" are not applicable to the office environment and therefore need not be audited for offices. You should spend at least an hour to do a thorough audit on all elements of the 5S, i.e., all 50 points have to be audited. If the finding is good, say how good it is and cross out the last column.

1. Sort: Stratification management and dealing with the causes

Sort	Audit finding	Action taken
Obsolete supplies red tagged and removed from the work place.	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Provided sufficient space for the supplies on the racks.	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Deal with the causes of dirt, leaks and noise.	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Organize cleaning of floors and house cleaning.	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Treat defects, leakage and breakage.	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Organize storage of parts and files	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
One location for each item	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
One stop service for customer	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
One day processing of ordering and receiving	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
One set of tools/stationery	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	

No of non-conformances:

/10

2. Set to Order: Functional storage and eliminating the need to look for things

Set to Order	Audit finding	Action taken
Are the supplies placed in their designated places?	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Visual interpretations and labeling with order quantities and re-order levels	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Usage frequency based placement for supplies	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
30-second retrieval supplies	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
First in, first out arrangement	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Functional placement for materials, parts, tools, etc.	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Straight line or right angled arrangement of shelf	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Eliminate covers and locks	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Zoning and placement marks	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Neat notice boards	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	

No of non-conformances: /10

3. Shine: Cleaning as inspection and degree of cleanliness

Shine	Audit finding	Action taken
Is the cleaning of the warehouse scheduled regularly	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Individual cleaning responsibility assigned	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	

Regular sparkling cleaning campaigns	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Cleaning inspections and correct minor problems	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Clean even the places most people do not notice	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	

No of non-conformances:

/5

4. Standardization: 5S standardization

Standardize	Audit finding	Action taken
Monitoring and updating the inventory frequently	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Has the unit actively maintained 5S by employing audit tools?	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Constant audit on expired supplies	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Levels of staff and top-management commitment to 5S?	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Constant education and training for employees on best practices?	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Inspection' OK' marks or Labels	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Responsibility labels	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Fire extinguisher and exit signs	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Danger zones signs and	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	

warning		
Fool-proofing practices	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Transparency in process	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Department/office labels and name plates	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Maintain cleaning schedules	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Constant improvement in inventory turnovers	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Prevent noise and vibrations	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	

No of non-conformances: **/15**

5. Sustain: Habit formation and a disciplined workplace

Sustain	Audit finding	Action taken
All-together cleaning	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Practice pick-up components and rubbish	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Confronting to OSHO guidelines for safety	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Practice dealing with emergencies	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
30-day audit program to sustain changes	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Execute individual responsibility	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	

Practice dealing with emergencies	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Good communication practices	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Practice safety measures (masks, helmet, shoes, etc)	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	
Education and training on 5S practices	<input type="checkbox"/> Non-Conformance <input type="checkbox"/> Conformance	

No of non-conformances: **/10**

Overall evaluation: _____ / 50

Total no. of non-conformances

0-5

6-10

11-15

16-20

> 20

Rating

Excellent

Good

Average

Marginal

Fail

APPENDIX II: GUIDELINES FOR A SUCCESSFUL IMPLEMENTATION OF LEAN IN HEALTHCARE WAREHOUSE OPERATIONS

1. Observation and Preparation - Assess the current status of the warehouse using tools such as value stream mapping, 5-Whys, fish bone, Circle of work, interviews and brainstorming sessions.

2. Planning

- a. ABC classification: Identify critical supplies which are high valued and frequently used.
 - i. Determine per supply annual inventory value (annual demand * supply cost)
 - ii. Sum overall inventory value
 - iii. Group 'A' category supplies, which form 80% of the overall inventory value. 15% for 'B' and 5% for 'C'
- b. Inventory model
 - i. Update ERP (Enterprise Resource Planning) software's for ordering and holding cost
 - ii. Note: Some ERP software's such as LAWSON will automatically calculate the EOQ (economic order quantity) and ROL (Reorder Level) once the holding and ordering cost are assigned
 - iii. Check the calculated EOQ and ROL values
- c. Redesigning the warehouse layout
 - i. Prepare a chart with the outline of the warehouse fit to scale
 - ii. Create small models of the racks, carts, etc.,
 - iii. Brainstorm with the employees to develop the new layout by pasting the models in the chart

3. Implementing 5S

- a. Pre-work - to compare the results of the current process to the improved process
 - i. If necessary, evaluate time taken for picking up supplies

- ii. Distance travelled
 - iii. Space occupied
 - iv. Mark the position of the racks using a blue tape on the floors
- b. Allocate the space for each supply based on the EOQ and ROP model. In our case we used 75% of (EOQ+ROP).
 - c. Group 'A' category supplies to reduce travel time and distance.
 - d. Conduct 5S events (Sort, Set to Order, Shine, Standardize, and Sustain)
 - e. Redesign the central supply layout, if necessary, and mark the floors with blue tape to identify the exact position of the rack.
 - f. If the locations of all the supplies are to be changed use the current 'stock-in-hand' report to avoid 'un-assigned supplies'.
 - g. Space allocation based on current supplies on stock rather than previous data
 - h. Clear outstanding purchase orders, else, it creates problems in assigning the new location in LAWSON or other ERP software. Consistently use a single report in any ERP software.

4. Post Analysis: Evaluate the improvements

- a. Measures: Distance, time, space and cost
- b. Monitor the inventory turnover for each month
- c. Use standard audit tools to evaluate the improvements of implementing 5S

VITA

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