COST-REDUCTION USING LEAN APPROACH IN RADIOLOGY DEPARTMENT OF NARAYANA MULTISPECIALITY HOSPITAL

Dissertation Submitted to

The IIHMR University, Jaipur

for the partial fulfillment for the award of the degree of

Master of Business Administration (MBA) in

Hospital and Health Management

By

Dr. Mahima Jha (P.T.)

Under the Supervision and Guidance of

Dr. Susmit Jain

2021

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DECLARATION BY STUDENT

I Hereby Declare That This Dissertation Titled **Cost-Reduction Using Lean Approach In Radiology Department Of Narayana Multispecialty Hospital** is the bonafide record of my original research work. I declare that it has not been submitted to any other university or institution for the award of any degree or diploma. Information derived from the published or unpublished work of others has been duly acknowledged in the text.

(Signature)

Name of Student Dr. Mahima Jha (PT)

Date 01-07-2021

CERTIFICATE

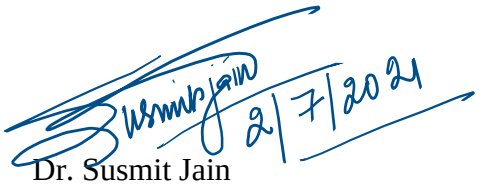
This is to certify that Dr. Mahima Jha (P.T.) in partial fulfillment of the requirements for the award of the degree of MBA (Hospital and Health Management) from the IIHMR University, Jaipur has successfully completed her internship at Narayana Multispecialty Hospital during March 22, 2021, to June 19, 2021.

Place: Preceptor/Head of the Organization

Date: Name of the organization

CERTIFICATE

This is to certify that dissertation titled **Cost-Reduction Using Lean Approach In Radiology Department Of Narayana Multispeciality Hospital** is a record of the research work undertaken by Dr. Mahima Jha (P.T.) in partial fulfillment of the requirements for the award of the degree of MBA (Hospital and Health Management) from the IIHMR University, Jaipur under my guidance and supervision and his/her approach to the research study has been sincere, scientific, and analytical.



Dr. Susmit Jain
Associate Professor & Faculty Guide
IIHMR University, Jaipur
Date: 02/07/2021

Dr. Dhirendra Kumar
Dean – IIHMR School
IIHMR University, Jaipur
Date: 02/07/2021

Abstract

Title of the Study: ***Cost-Reduction using Lean Approach in Radiology Department of Narayana Multispecialty Hospital***

Submitted by: Dr. Mahima Jha (P.T.) **Guided by: Dr. Susmit Jain**

Hospital Administrators are continually looking for ways to reduce the cost and expenditure related to healthcare services. The radiology department is one of the key areas for reducing the expenditures of the hospital. The radiology department is an important revenue-generating department, but it also houses one of the costliest technologies to maintain and repair. The objective of the study was to reduce the cost in radiology department without compromising the quality of services. The study design is descriptive & cross-sectional, and data of cost analysis was obtained from the Hospital Information System. The period of the study was over a three-month period between March - June 2021. Data of Radiology Information System (R.I.S) Moksha (medical imaging software) was also used. The cost related to radiology was determined for the consumables for three weeks. The sampling technique was purposive. Data was analyzed using MS Excel. Value Stream Map was created, and 8 types of wastes (lean tool) were identified in the study. Value chain and Pareto analysis of the materials was also done. The total consumption value of consumables of 28 items was 598598.282 (over three months Mar-May). After the Pareto analysis, 2 items out of 28 are found to be of A category, and 24 items are found to be of C category. The items of A category comprise 73.3% of the cost, B consists 18.5 %, and C category consists 8.2 % of the total cost. Category A materials

are the most expensive and require strict control. The average consumption as the part of the revenue was 4.59% in 3 months. From the data analysis, it was observed that stringent control on consumption, monthly consumption analysis, and commitment of the staff members could be the contributory factors for the reduction in expenditure. The maximum scope for cost reduction in the radiology department was in the MRI Studies. The adoption of the recent strategy of providing CDs, instead of films for MRI studies could reduce the film's utilization for MRI studies. To reduce the cost related to stationery and paper consumption, greater attention should be on linking the RIS with NH Care mobile app. Eliminating paper records is another money-saving approach. The purchase department must be informed of the consumption pattern of Contrast materials every week. The measures for cost reduction in the radiology department could be optimum utilization of contrast material and X-ray films, digitalization of services, centralized buying unit for procurement, and the use of IT.

Keywords: Radiology, Lean, Consumables, Radiology Information System, Value Stream Map, Pareto Chart.

Acknowledgments

The report has been prepared for the dissertation for fulfilling the requirement of the course MBA in hospital and healthcare management.

The purpose of the dissertation report is to be familiar with the practical aspects and use of knowledge to clarify the career goals.

I would like to express a sincere and honest thanks to **Dr. Vijay Pratap Raghuvanshi**, General Manager Administration, Narayana Hospital, Jaipur, and **Mrs. Nabalina Datta**, Head of Purchase Department, Narayana Hospital, Jaipur, for their help and cooperation during the study. Their expertise and advice were of great help for the dissertation report.

I would like to express my gratitude to my Dr. Susmit Jain, Associate Professor & Faculty Guide, IIHMR University, Jaipur, for giving his valuable time and guidance, without his support this could not have been possible.

I would also like to thank my parents and friends for their support during the period of the dissertation.

Name: Dr. Mahima Jha (P.T.)

Roll no.: 929

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ACRONYMS/ABBREVIATIONS

CT = Computed Tomography

MRI = Magnetic Resonance Imaging

X Rays = Röntgen radiation

PACS = Picture Archiving and Communication System

RIS = Radiology Information System

OPD = Out Patient Department

IPD = In-Patient Department

CTVS = Cardio Thoracic Vascular Surgery

MICU = Medical Intensive Care Unit

SICU = Surgical Intensive Care Unit

PICU = Pediatric Intensive Care Unit

PGW = Pediatric Ward

ANC ward = Ante Natal Care Ward

CCU = Coronary Care Unit

HDU = High Dependency Unit

ECHS = Ex-Servicemen Contributory Health Scheme

CGHS = Central Government Health Scheme

HIS = Hospital Information System

Chapter 1. INTRODUCTION

Hospital Administrators are continually looking for ways to reduce the cost and expenditure related to healthcare services. The radiology department is one of the key areas for reducing the expenditure of the hospital. The greater pressure on cost containment has an impact on hospital operations. The aim of the study is to contain the cost without compromising the quality of services and the challenge is to maintain the balance between the two. The radiology department is an important revenue-generating department, but it also houses one of the costliest technologies to maintain and repair. For example, cost of an MRI Machine for GE Systems 1.5 Tesla ranges from 80 Lakhs to 8.5 crores, the CT Scan machine ranges from 80 lakhs to 3.8 crore and X Rays machine ranges from 1.5 lakhs to 75 lakhs (Indiamart). The cost reduction is helpful to patients as well as the hospitals. Cost containment is a challenge as the cost containment of one person can be another person's income or revenue. During the period, the cost of health care for people has grown at an exponential rate. The cost upsurge over the years and the expected cost increment requires close management.

"Around 35-40% of the budget of healthcare organization budget is spent on procuring and purchasing the material and supplies" (YİĞİT, 2016). The decisions related to cost influence the radiology department and the care of patients daily. The need for containing and controlling the imaging cost requires the understanding of procedures and quantify the cost of the imaging services.

The radiologist or health care providers play a leading role by collaborating with administrators and other staff members to derive procedure-specific costs that help in accurately depicting the resource utilization. The diverse nature of value and cost of radiology gives rise to a complex set of dynamics, with various items to be purchased, consumed, and in turn influence the cost of the images which is the primary product. The focus must be on generating value from the products. “To compensate for the projected revenue reduction, facilities will need to reduce cost 15%-25% by 2020.” (Lipcamon, 2015)

Lean tools are adopted by many radiology departments of the hospital as they "improve the operational efficiency, eliminate waste and optimize the value of their services. The lean approach is adopted from the automobile manufacturing industry. The lean principles lead to transformation due to standardizing the workflow, involvement of the staff, and use of specific tools for data collection and analysis.

The lean approach is based on continuous improvement in performance with the goals of adding value to the services and achieving the highest customer satisfaction.

With the rise of medical technology, the expenditure on medical materials is increasing disproportionately. For the utilization of the limited resources of the hospital, the health managers must use scientific inventory control methods.

Cost containment is essential for healthcare services due to rising material costs.

The hospital management has a responsibility to the community—to provide health care services that the community needs, at an acceptable level of quality and the least possible cost.

Cost finding and analysis can support departmental managers, hospital administrators, and policy-makers to determine how well their institutions meet these public needs (Shepard et al. 2000)

In this dissertation report, the material consumption and cost of the items used in the radiology department were analyzed and the various methods of cost reduction deployed in the department are described.

What is the lean approach?

Lean is a set of operating philosophies and methods that help create a maximum value for patience by reducing waste and waits. (Adegboyega K Lawal1, 2014)

It has its origin in the Toyota car company production line. It is a quality improvement system that helps in improving the process in inventory management, production, and other quality improvement techniques. the personnel using lean as a method of continuous learning and quality improvement technique is known as lean experts.

The lean investigations were first applied to health care in Virginia Mason medical center. After the success of lean in Virginia Mason center, it became the benchmark or catalyst for lean healthcare in health care settings.

Many Japanese terms are used to understand the mean strategies. The most often used and reported is Kaizen.

Other tools all used to implement the lean are value stream mapping and 5 S,

The five S stands as Sort, Sweep, Simplify, Standardize and Sustain.

Value stream mapping is used in healthcare as a visual tool to find out the patient flow, material supplies, information related to the journey of patients, etc. It maps all the operational processes which are necessary for health care service delivery. All the activities related to the service are reported and visualized. Other examples of the lean tools are Kanban, lean leadership training, 8 defects, error proofing.

Kanban is a tool in the form of a card that indicates the requirement of reordering supplies.

An error-proofing or mistake-proofing project has the aim to develop a procedure that avoids another error. It is used as a futuristic approach.

The outcomes of the Lean approach are in the form of health system improvement such as reduction in turnaround times, the average length of stay, discharge rate, near-miss event, waiting time, etc.

Patient outcomes are in the form of patient satisfaction and mortality rate. The supplies should be available whenever and wherever they are needed. It is necessary for a large range of procedures to be completed efficiently and in a safe manner. The goal is to reduce waste and the variation in the supply chain. The ultimate aim is to improve patient care and patient safety.

Why Lean Approach?

Lean production is based on the philosophy of Toyota production systems. The main focus of the Toyota lean approach is on the efficiency of the resources utilized and how the value is generated. It is also known as the Toyota model. Applications of Lean are currently being applied to the health care industry. The lean approach has successfully demonstrated its applications in the health care industry. It is a holistic approach to change an overall business strategy. Though lean started from the production industry, the research on its use in the health care industry is limited. Lean has its application in almost all sectors of the health care system. It includes hospital, primary care, management, administrative staff, health care professionals, and support staff.

Chapter 2. Review of Literature

Table 2.1

Reference	Date	Design/Methods	Aim of the review	The main conclusion stated by the authors
Kadom N, Itri JN, Trofimova A, Otero HJ, Horný M	2018	Cost-effectiveness analysis	To review key features of cost-effectiveness analysis and its issues related to radiology	One of the critical aspects related to the technological advances of radiology is proving that values outweigh the cost. As the cost of the technologies is higher, not everyone in society can afford the diagnostic and screening procedures. One of the scientific methods to contain health technologies for better utilization of the resources is the cost-effectiveness analysis.

Reference	Date	Design/Methods	Aim of the review	The main conclusion stated by the authors
R. D. Geofrrey	2017	A descriptive study using time-driven activity-based costing	1.Describe how costs differ depending on the perspective of the stakeholder n 2.Explain why radiologists must understand costs and costing methods to articulate the value of their work 3.Describe the factors that influence	Approximately 75 % of the hospital costs are fixed, direct, or overhead costs, and the allocation of these costs across the range of medical services is a huge challenge. Hospitals take a top-down approach to costing depending on one of two methods: the ratio of costs to charges or the assignment of relative value units. ABC is a two-stage process that first assigns resource costs to discrete tasks or activities and the costs are assigned to a final product or service based on the use of the service. Identification and quantification of cost drivers

			indirect cost allocation n 4.Describe the advantages and disadvantages of various methods for measuring and reporting costs	are done for each activity that contributes to a final product or service.
Moodley I & Moodley S	2015	• Incremental cost analysis • Questionnaire-based survey	To conduct the cost analysis of PACS compared with conventional radiology	The advancement in radiology such as digital technologies leads to the elimination of the films and the paper-based reports used for the reports. It has also improved the workflows. PACS can control the various financial outcomes of the department but it also requires a financial investment at the beginning with a total cost that also includes RIS. Therefore,

				careful financial consideration should be applied. For the determination of the actual cost, true monetary and non-monetary aspects should be taken into consideration
Megan M Rose	2017	• Literature review • DMAIC model	To determine whether a lean six sigma approach in supply chain models would improve outcomes and financial savings	The goal of the Kanban system is to deliver a required amount of supply whenever needed. It is displayed in the form of a visual sign such as a card or box. The supplies can be stored in 2 boxes. After the first box is emptied, it is placed in an area that is visible to everyone. It signifies that the item needs to be stocked. The author conducted a project in the cardiac catheterization and

				interventional radiology unit of an urban Midwestern hospital. There were many complications in the supply chain of the hospital. After collection, the baseline data demonstrated many missing supplies, items that were expired, and overnight shipments. The lean six Sigma-based approaches were applied in the supply chain interventions and procedures. This resulted in improvement in outcomes, cost reductions leading to financial savings. All of the results depicted reduced waste and variation. The savings which the department achieved demonstrate lean six Sigma as a promising approach for

				improvements in the supply chain. The annual savings of $5700 was noted as a result of a reduction in overnight shipments.
Ruben I Cohen	2018	To review lean methodology in healthcare	Review article	Lean is a method of quality improvement that originates from its success in Toyota production systems. The management of Toyota cognized that a high-value product should come at a competitive price. The main concept is based on the elimination of operations which are not adding any value from the point of view of customers. TPS was successful in reducing the inventories by using the concept of just in time. All the processes were

				streamlined in such a way that every step provided the required quantity with the required time. New procedures were practiced by employees correctly and safely taking less amount of time. For all the information needed for the quality improvement processes, TPS used data collection and used statistics for process control. The 5 S method was also described. Sort: only the material which is required for work is identified and the others are discarded. Set in order: the items are situated and placed in the order of flow.

				Shine: cleaning of the work area. Standardize: the duties and roles of the staff are identified and the standard tasks are defined. Sustain Most difficult part as it requires discipline. Lean is recognized as a means of transformation in a culture that changes the way a health care organization operates. The author explained the issues with lean. It sometimes can be focused on a single process rather than the whole system.
Vahit	2016	ABC, VED, and ABC VED Matrix analysis	To analyze the annual medical expenditure	The author used inventory control techniques such as ABC, VED, and ABC VED matrix. The hospital chosen

			using the ABC VED matrix	for the study was a 600 bedded University Hospital in Turkey. The study was conducted by using the data for the financial year 2015. the data was taken from the records of administration and fine ends and then analysed in MS Excel spreadsheet. He explained that 30-40% of the budget of the health care organizations is spent on the purchase of medical materials and supplies. an effective and efficient inventory control management is required for the medical materials. Quality health care services can be provided by applying and using material management, and inventory control techniques. Inventory was

				described as one of the major current assets of the hospital. The ABC method is very important for the criteria of cost. It is based on the classification of drugs and materials as per their relative importance. the VED analysis is based on criticality. Total 15101 items were identified with an annual expenditure of 1024701701. The items were categorized in AB and see categories. 12% of the items what is the category of a 21% what in the category of be and 67% what is the category of seeing. the annual expenditure of item a was 69.93%, for item B 20.06%, and for the item, C is 10.02%. for the VED analysis, 165 items one in the

				category of B 1025 but in the category of E, and 311 lies in the D category. The author concluded that class 1 map vital medical items should be under the control of top management as it requires the greatest amount of attention. The consumption of the items and their stock level should be monitored continuously and the safety stock is to be kept low. The items lying in the category two and three should come under middle and lower Management. Category 2 consisting of essential items must have moderate control and category three items need to be purchased periodically

Kruskal et al	2012	Literature review	■ Describe the lean approach to improving organizational performance and how it differs from other approaches ■ List the fundamental principles that must be consistently applied when implementing a lean transformation. ■ Provide an example from each of the four categories of tools that	To implement a lean approach to improve organizational outcomes require to always keep in sight the goal, consumer needs. The journey of the lean transformation begins with a single step. The process requires organizational commitment. The involvement and contributions of every staff member are valued and appreciated

			can be used to create and maintain	

Chapter 3. Methodology

RESEARCH QUESTION

Q1. What are the various methods of cost-cutting without compromising the quality in the radiology department of Narayana Multispeciality Hospital?

Q2. How is the cost analysis of material consumption in the radiology department conducted in Narayana Multispeciality Hospital?

RESEARCH OBJECTIVES

Objective 1. To study the workflow of the radiology department of Narayana Multispeciality Hospital.

Objective 2. To determine the various methods of cost-reduction in the radiology department of Narayana Multispeciality Hospital.

Objective 3. To conduct a cost analysis of the material consumption in the radiology department of Narayana Multispeciality Hospital.

Methods: STUDY DESIGN: Descriptive, Quantitative, Cross-sectional study

SETTING: Narayana Multispeciality Hospital, Jaipur

SAMPLE SIZE COLLECTION: Data of cost analysis is obtained from the Hospital Information System. The cost related to radiology was determined for the consumables. Data recorded on RIS MOKSHA was also used. Weekly data for consumables was compiled for 3 months.

SAMPLING TECHNIQUE: Purposive Sampling

SAMPLE SIZE: 241 sampling units – cost of items indented during the study period.

STATISTICAL METHODS: Data analysis was done through MS Excel. Value stream mapping was also included. TIMWOODS is incorporated in the study which is a lean tool that stands for 8 types of defects: Transportation, Inventory, Material, Waste, Over-processing, Overproduction, Defects, Staff. Value chain and Pareto analysis of the material was done.

OPERATIONAL DEFINITIONS

Cost-cutting

Cost-cutting refers to measures implemented by a company to reduce its expenses and improve profitability. They can also be enacted if a company's management expects profitability issues in the future, where cost-cutting can become part of the business strategy.

Radiology

Radiology is the medical discipline that uses medical imaging to diagnose and treat diseases within the bodies of animals, including humans.

"Cost Containment: A detailed plan and process of maintaining organizational cost and purchased prices within certain specified target limits over a period of time."

"Cost Avoidance: An effort to prevent or reduce supplier price increases and ancillary charges through the use of value analysis, negotiations, and a variety of other techniques."

“Cost reduction: A reduction in the costs incurred by an organization which has tangible results; i.e., a reduction in outside spend and/or the availability of funds that can be used for purposes other than originally intended.” (Singh, 2017)

"Cost: The monetary value of resources used or sacrificed or liabilities incurred in the performance of an activity based on the utilization and price of labor, equipment, and supplies, as well as the assignment of overhead"

"Direct cost: The cost of resources directly consumed by an activity"

"Indirect cost or overhead cost: A cost that cannot be identified specifically with or traced to a given cost object Housekeeping services, building, and grounds maintenance, utilities "

"Fixed cost: A cost that does not vary with the volume of activity. Incurred regardless of whether a procedure is performed or not. "

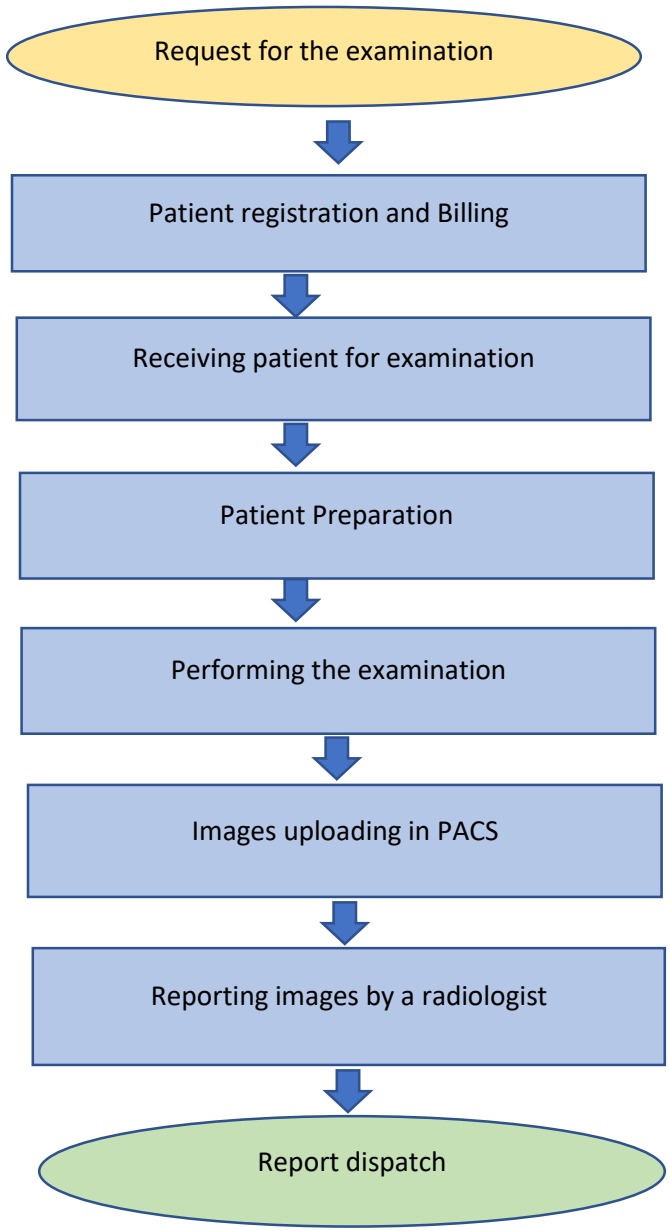
"Variable cost: A cost that varies with changes in the level of an activity, when other factors are held constant. If the procedure is not performed, then there will be no cost"

ETHICAL CONSIDERATIONS:

Due permission from the authorities and considerations of confidentiality and privacy would be undertaken in the study.

Chapter 4. Results

Figure 4.1 Workflow of the radiology department



After the request for examination, the first step for every OPD patient is registration at the billing counter for his/her examination. The staff at the billing counter asks about the history of diseases such as hypertension, diabetes, and cardiac health conditions, allergies to the contrast, surgeries, metallic implants, etc. A consent form is filled for the MRI scan.

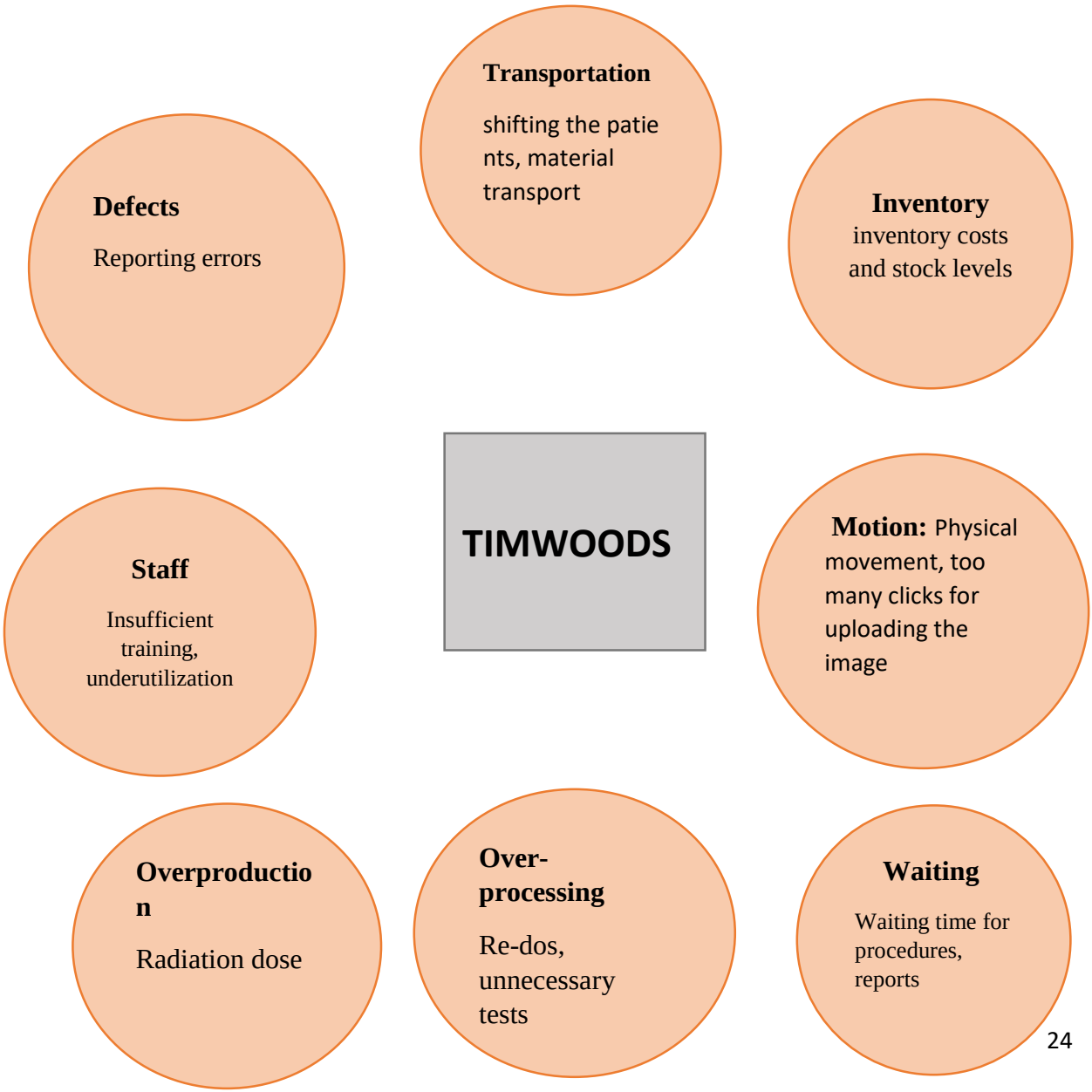
When the process of registration is completed, the patient is directed to wait for his/her turn.

The patient is called for the examination and the patient is prepared for the examination. The technician explains the procedure to the patient in brief.

The images for the examination are uploaded in PACS. From PACS, the radiologist can view images and the process of reporting of images starts.

The images are read, reports are finalized, and then uploaded in the RIS. The RIS is integrated with the HIS and the reports can be printed and dispatched afterwards. The reports are then collected by the patient at the designated time.

Figure 4.2 Lean tool: TIMWOODS



8 types of defects:

Transportation

Inventory

Material

Waste

Over processing

Overproduction

Defects

Staff

1.**Transportation:** The transportation type of waste takes place while shifting the patients from wards/ICU to the radiology department. It also occurs while shifting the patient back to the respective ward or ICU.

Transportation of patients takes a great deal of time and it requires communication on the part of technicians as well as nursing staff in the wards.

The subsequent delay in the transportation and the time between the billing and procedure adds to the waiting time of the patient. The waiting time increases in the case of delays in transportation.

The transportation delay also occurs when the portable machines are shifted from the department during a bedside procedure. Furthermore, transportation can lead to the wear and tear of the machine leading to an increase in the cost of maintenance.
The shutdown time of the machine during maintenance also adds to the cost.

2. **Inventory**: the inventory contributes to the material expenditure and consumption both add to the cost of the department. Both the inventory costs and increase in the stock levels act as a burden to the hospital's financial performance.
The inventory is under the control of the purchase department of the hospital.
The strict control of the inventory is always kept.
Excess inventory or low inventory are both responsible for the rise in expenditure by the department.

3.Motion: Requirement of too many clicks for loading and uploading the image in the PACS

4.Waiting: Waiting accounts for waste and is measured as the waiting TAT for the department. It can occur as
1) Waiting time for the procedure – the time between the patient arrived at the counter to the time of the procedure.
2) Waiting for the report generation - it is the time between examination/procedure and the report finalization by the radiologist
3) Waiting time for receiving the materials from the store

4) Waiting time for the material supply from the vendor

5.Over-processing/non-value-adding processing: this type of waste occurs when more steps are added to the procedure than required or doing more work or producing service than required.

The over-processing on the department occurs as a result of unnecessary tests performed.

The re-dos are done for CT, MRI, and X-ray which all adds to the over processing and increases the cost of the department.

6.Overproduction: This type of waste occurs when products and services are delivered before they were required.

The radiation dose in excess can be an example of overproduction.

7.Defects:

Defects occur when the products are not deemed fit for use.

They add unnecessary costs to the operations of the department without adding any value.

Reporting errors are the defects in the radiology department.

The reporting error can occur before the report is dispatched or after the report is dispatched.

8.Staff:

The 8th waste is the waste of unutilized human resources. This happens when the staff is not involved in the management processes such as planning, organizing, controlling, and innovating. The staff should also be included in the overall process and quality improvement and should be encouraged to come up with ideas by the management.
Another type of waste is because of insufficient training. Due to COVID-19 restrictions, training sessions were not conducted for the staff during the study period.
When the machine is idle or underutilization of the machine takes place in the department, the human resources also remain unutilized.
The staff should be motivated, encouraged to give proper feedback, and challenged to come up with new ideas at work.

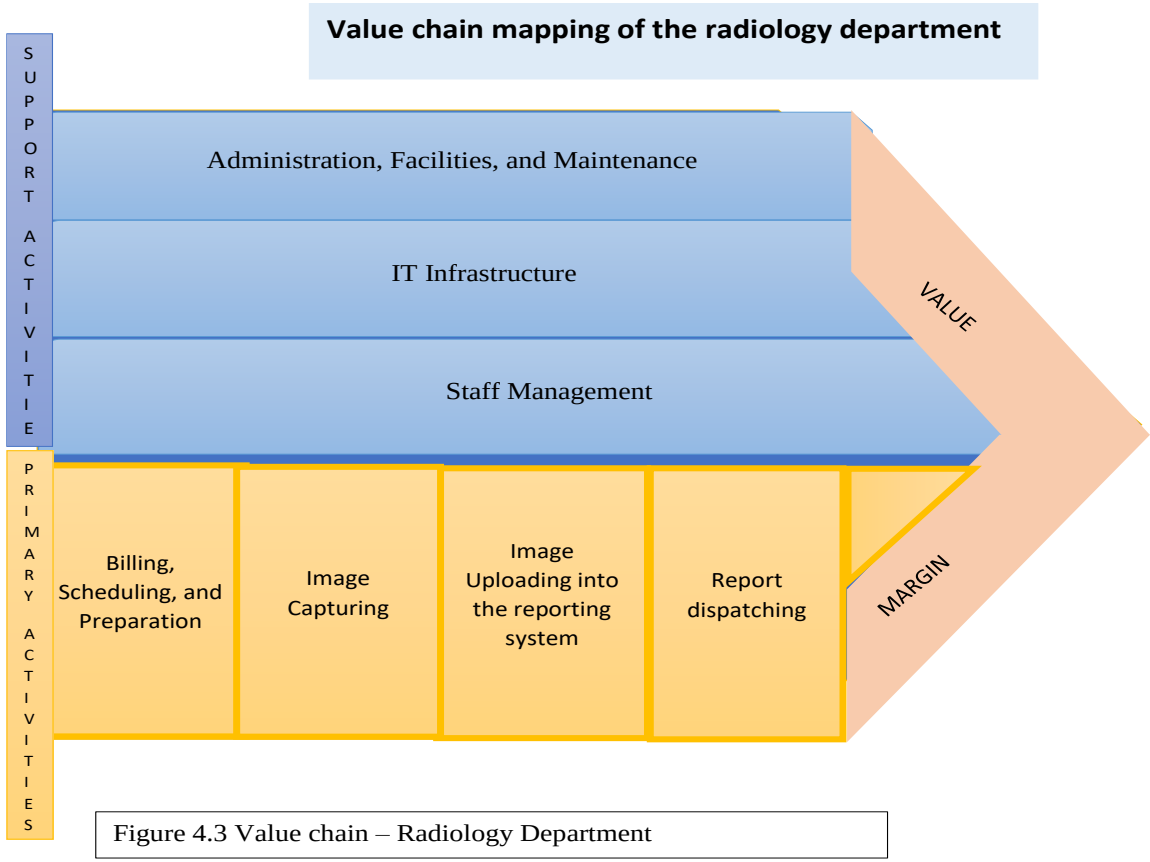
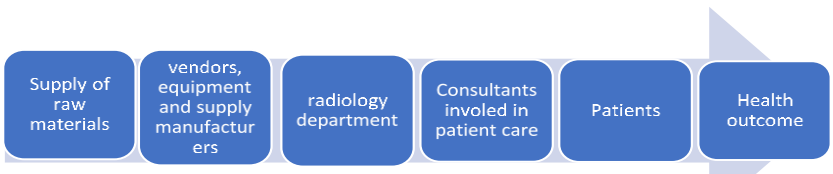


Figure 4.3 Value chain – Radiology Department



The value chain of the radiology department is in the form of various complicated dynamics, the value chain consists of a list of primary and supporting activities. The primary activities of the organization in order adds to the value of the services or products offered.

The key support activities are also known as indirect activities. The support activities have applications throughout the organization's structure. These activities contribute to an outcome which is the main services offered.

The support activities of the department are administrative services, the facilities of the department, and the maintenance in the form of contracts such as Annual Maintenance contracts and CMCs. These activities contribute to an outcome which is the main services offered.

Human Resource Management is a significant part of the activities as it is necessary that the staff remains motivated, punctual, and utilized properly.

The IT Infrastructure of the department is also an important support activity. The software support acts as the backbone for the production and distribution of radiology images and reports. The IT infrastructure in the form of software products such as RIS, PACS, and EHR are necessary as they help in uploading and retrieving reports whenever required.

The primary activities in the radiology department are Billing, Scheduling and Patient Preparation, Image Capturing by the technicians, Uploading the images and reports into

the reporting system after finalization of the report, and ultimately dispatching the reports to the Patient at the radiology counter

These activities proceed to the value generation to the customer. In the case of the radiology department, the value creation services are images, images derived information such as reports and films.

The value-generating activities also add the margin for the hospital.

The value chain of the organization acts as a link in the value chain of the industry from the single value chain from the suppliers to the end consumer i.e. the patient.

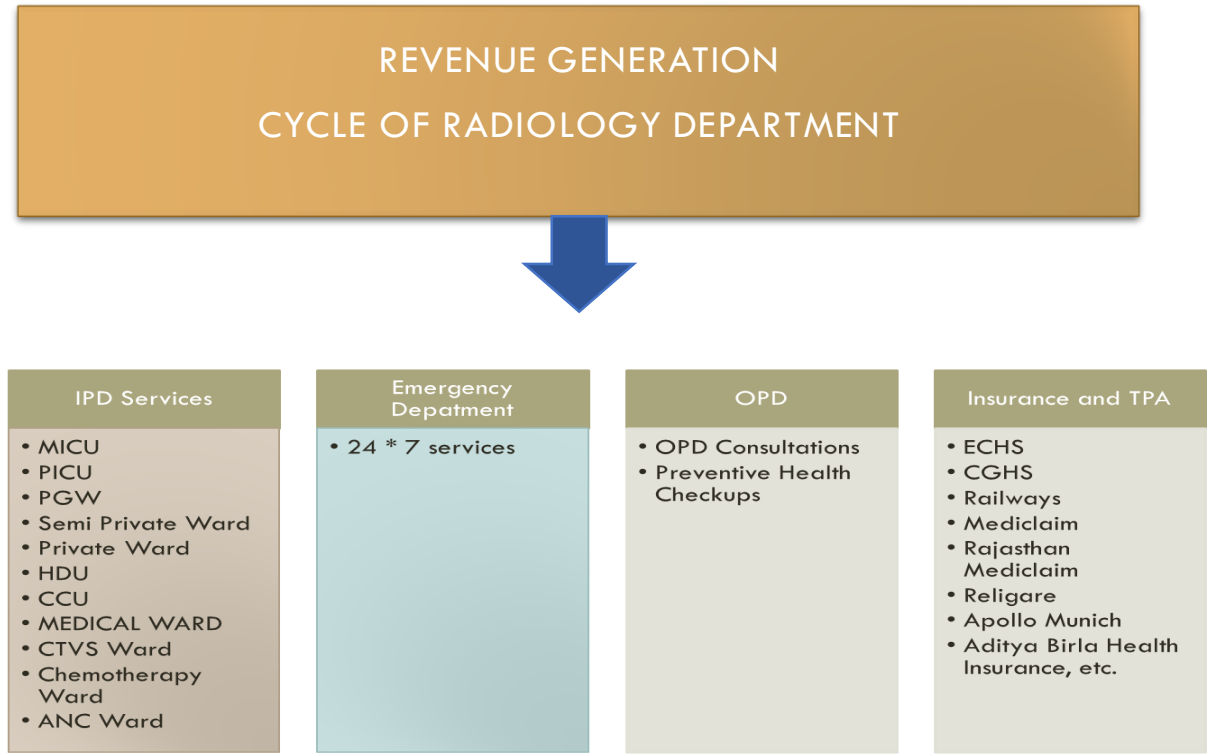


Figure 4.4 Revenue Generation Cycle of Radiology Department

The radiology department has a revenue generation cycle. The department follows the pay before service structure. The billing process consists of generating multiple bills for the patient. The bills are submitted to the service provider and a copy of them is kept with the patient. The following services have a direct relationship with revenue generation.

The revenue for the department is generated from the IPD and OPD services at the hospital. IP service consists of ICU, Wards, Semi-private, private, chemotherapy, and general ward. The Emergency Department which is functioning 24X7 is also a source of revenue generation. Revenue is also generated through the patient with insurance and third-party payers. The OPD consultations are the major source for the revenue generation of the department. Other sources of revenue are the Second opinion by the radiologist.

The revenue is calculated by the Service analysis of the department. It is summed up with the Service Inside the package. The calculations for both are done on the weekly basis. The calculation for the 5 weeks of the month summed up to be the revenue of the department.

The consumption of the department is updated daily online by the staff and technicians performing the examination. After the calculation of the revenue, the monthly consumption is calculated in the same manner. A strict check on the consumption is kept by the administration.
The revenue per test and the cost per test are calculated.

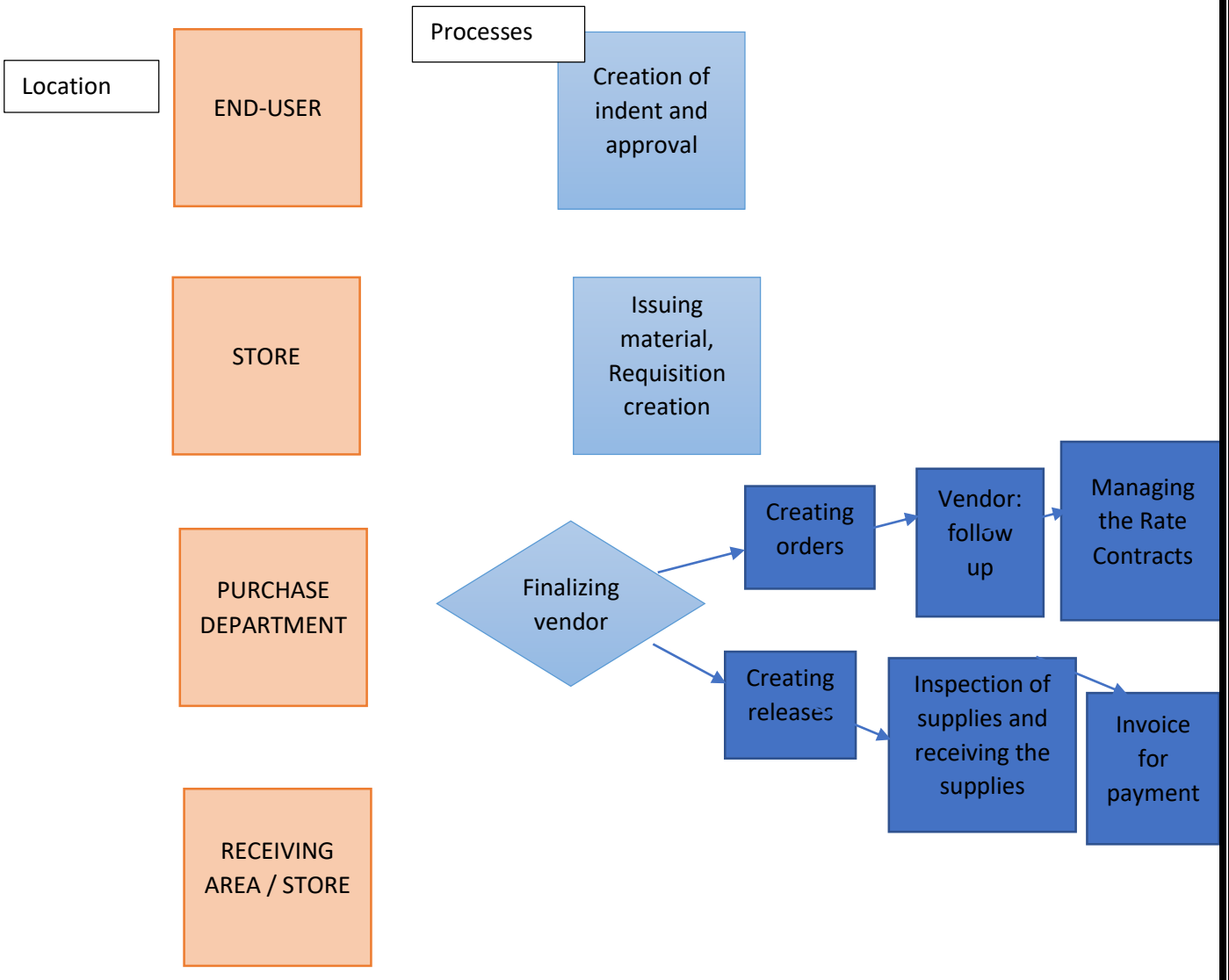


Figure 4.5 Overall unit process flow

The scope of the material inflow includes all material purchases such as consumables, materials, drugs, implants, etc.

The quantity of the order depends on the consumption pattern and the current level of stock.

The objectives of the material planning are:

- To prevent any stock-outs and service level is ensured
- To reduce cost by reducing the inventory days whenever possible.

3 factors are kept in mind for the consideration of material planning logic for each unit. I.e. Consumption pattern, current closing stock, vendor lead time, etc.

Material planning is done by the Unit inventory head of purchase department.

The items are indented with the required quantity and they are aligned with brands following the current purchasing policies. The item should match with the specific code assigned,

Standard logic is maintained for the consumption following the pattern in such a way that the order quantity is determined. Adjustments can be made based on the variable items. The approval is done by the department in charge.

The purchase department then finalizes the vendor and creates orders. follow up from the vendor is done by the purchase department and the rate contracts are maintained.

The items are taken to the receiving area before the inspection. The quantity ordered is matched with the amount ordered and visual inspection of the items is carried out.

The items are checked for damages, packaging, brand, batch, expiry dates, manufacturer marking, shelf life, fungus growth in IV bottles, etc.

The stock is inspected to ensure that the items adhere to the quality stated in the purchase order. The receipt of the items is recognized in the system.

The process includes three-way checking of the vendor invoices from Purchase Order rate to GRN rate to invoice rate and all invoices are documented in the system for the timely generation of payment. The damaged items are rejected to the vendor.

After the inspection is satisfactorily finished, all the invoices are entered into the Bill Entry book in which the Vendor's name, invoice number, date, delivery date, etc. is mentioned.

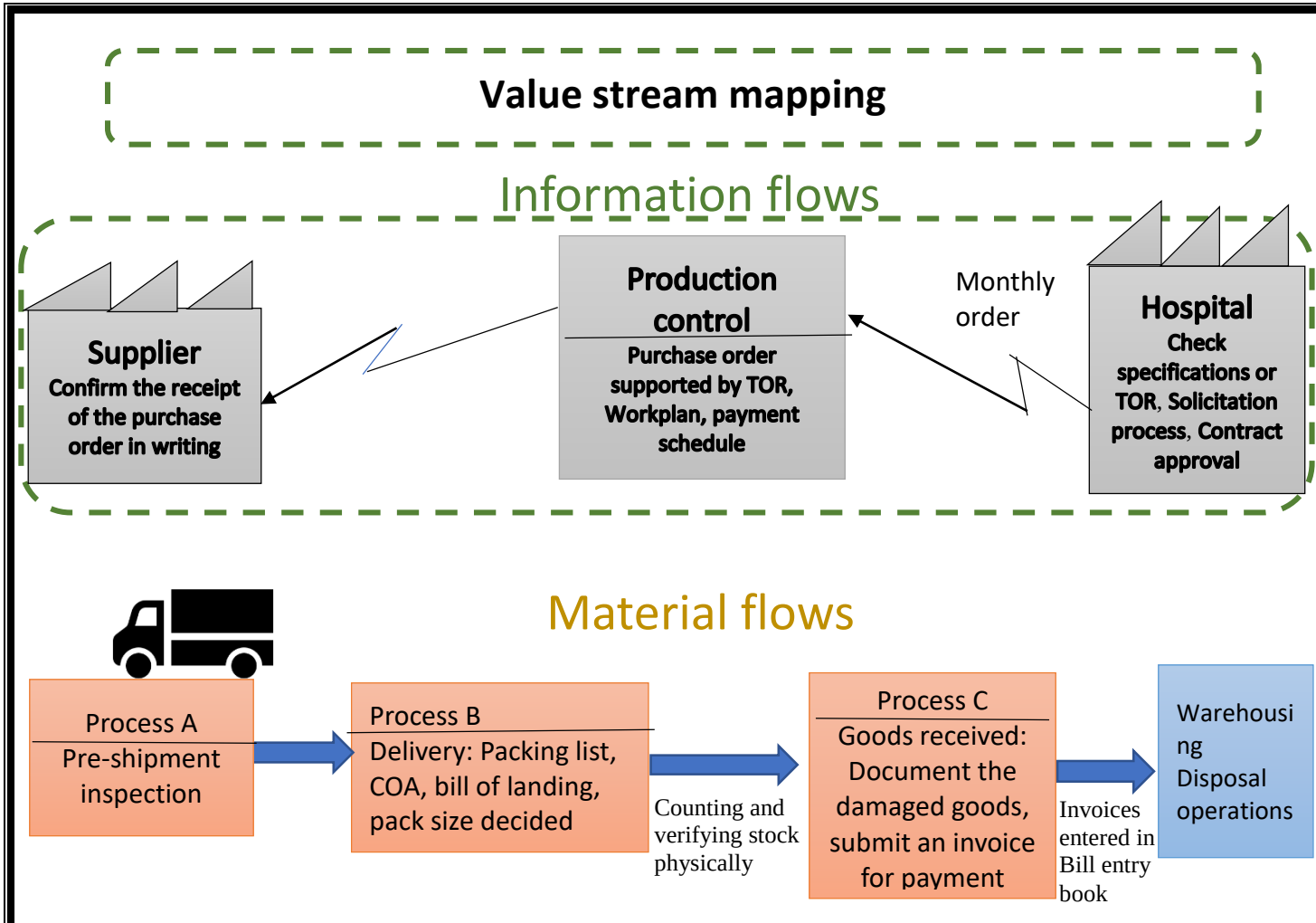


Figure 4.6 Value Stream Mapping of Radiology Department

The lean tools analyze the current situation to divide the processes into value-adding and non-value-adding activities. Value stream mapping is a tool that helps in achieving that as it is one of the most efficient ways for classification. the whole process is converted into a map that shows those services. it displays the service line with symbols. the structure of the value stream is minimal.

The value stream mapping starts from the first step of obtaining the raw materials from the vendors.
The map displays the bottlenecks and is used as a visual tool. the activities are classified into nonvalue-adding activities also known as waste. the waste should be eliminated for improving the processes.

The current state of the radiology department of the hospital is prepared and showcase as the value stream map. the cycle times of activities are noted.
The bottom line shows the non-value-added activity.

The process begins with the pre-shipment inspection of items. so the purchase of an item is decided in two
ways i.e. either locally or through a central buying unit. the sample of the product is sent to the central formulary. the product is then used and analyzed for its quality.

Pricing is decided through the central buying unit or locally in some cases. the product feedback health and deciding the rate of the item. A contract of one year is signed. It is a one-time process.

The second step is product selection. For this distributer turnaround time is six to seven days. The pack size of all the items is decided.

All the items are verified by visual inspection. The criteria for inspection:
Proper inspection should be done before taking the items in-store/receiving area
Visual inspection is carried out of packets/boxes to match with the quantity ordered.
The quantity accepted is matched with the quantity invoiced

Physical inspection is done for

- Damages in items and their rejection
- Open or cut packaging
- Marking of the manufacturer, brand, batch, and expiry dates
- Shelf life (time till expiry) should be of minimum 180 days
- Broken bottles and empty vials
- Cold chain items- proper packaging is done or not

The goods are received in the facility and they are inspected for the bill, purchase order and checked for quantity and damages. If the item is found damaged the prize is changed or the invoice revised.

After the completion of a satisfactory inspection, all the invoices are entered in the Bill entry book. In the bill entry book, vendor name, invoice number, invoice date, the delivery date is entered

The last step consists of goods received a note in the main store. The items are distributed in the radiology department. The lead time is 24 hours.

Data analysis and interpretation

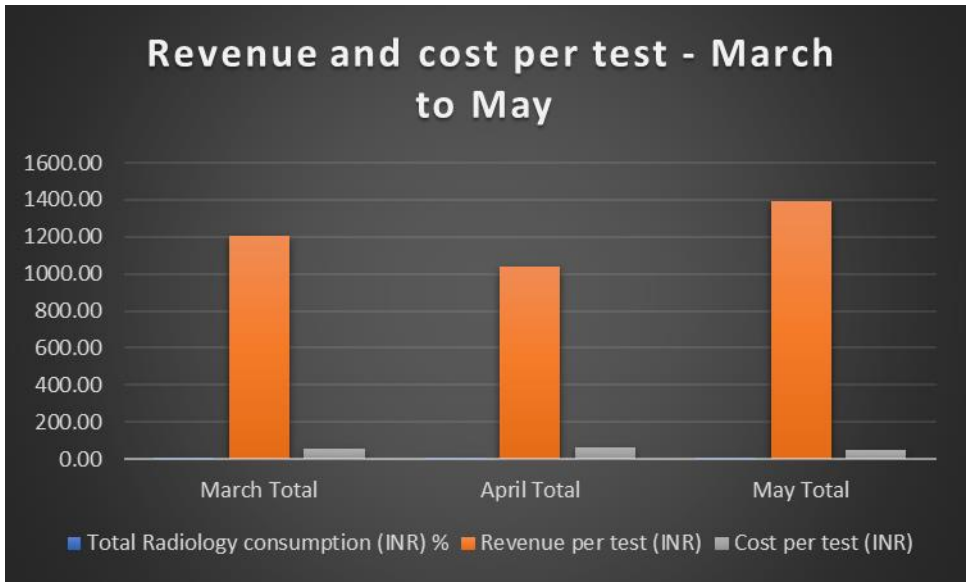


Figure 4.7 Revenue and cost per test – March to May. Radiology Department

	March Total	April Total	May Total
Total Radiology consumption (INR) %	4.37	5.79	3.61
Revenue per test (INR)	1,208	1,037	1,394
Cost per test (INR)	53	61	51

Table 4.1 Radiology Consumption Analysis

The data is collected during the period of 3 months i.e. from March to May. The analysis is done in MS Excel. The revenue exceeds the consumption during the whole study period. During March, the total radiology consumption is 4.37 % of the total revenue and the cost per test was 53 as compared to the revenue per test i.e. 1208. For April the total consumption was 5.79 % of the total revenue. The cost per test was 61 and the revenue per test was 1037. The consumption was least in the month of March i.e. only 3.6 % with the revenue per test as 1394 and the cost per test is 51. Thus the month of May was the most cost-effective. The consumption also varies depending on the number of tests done in the month as well as the type of studies.

For example, the studies requiring contrast require more expenditure in the terms of contrast material. As a result, the consumption of the department increases.

The radiology department follows many cost reduction techniques to reduce the expenditure of the material. The film's utilization is an excellent example of this.

The department utilizes the film size 14 x 17 inches in X-ray by dividing it into 4 portions. This thus helps in reducing the cost required for one film of X-rays.

The efforts for cost reduction are more evident in the following graphs.

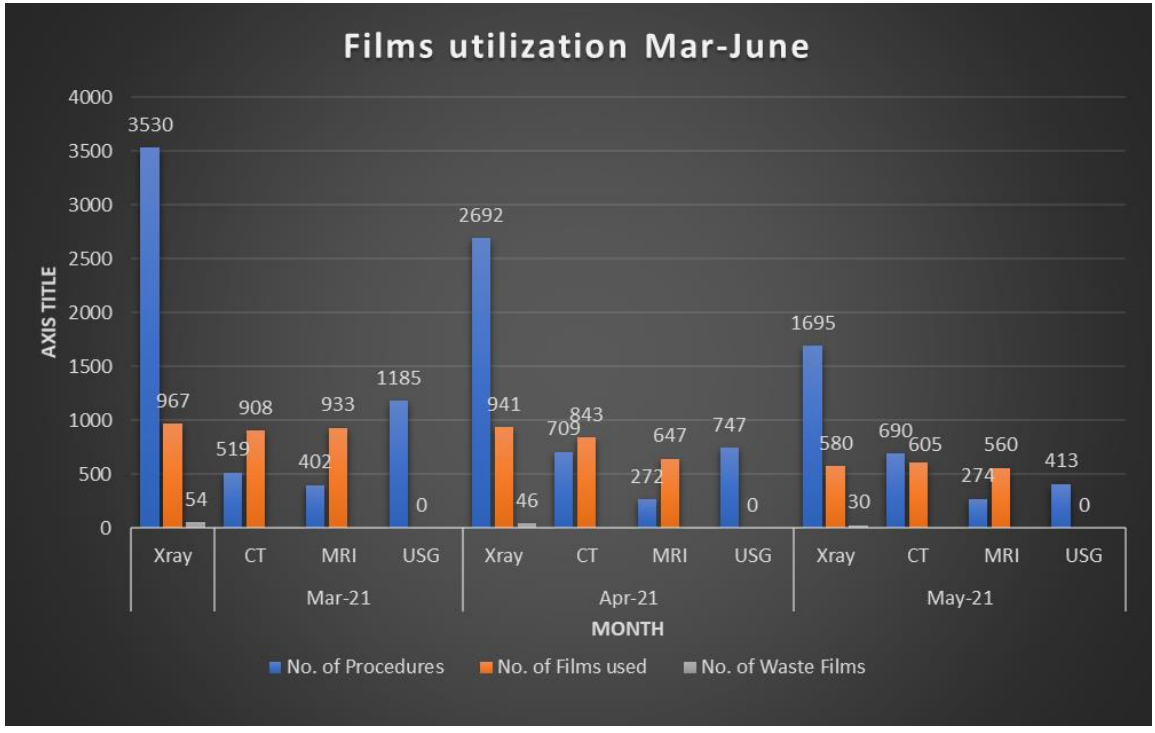


Figure 4.8 Films utilization from March to May

The film utilization is analyzed from March to May. As films constitute a large portion of the consumption of the department and value-generating, the analysis of the film utilization as well as the consumption is essential. The film utilization is most effective in X-Ray. The number of films utilized is 967 for March for the total 3530 procedures i.e. 27.4 %. It is 941 for 2692 procedures in April i.e. 34.95 % and 580 for 1695 procedures in May i.e. 34.32 %.

The greatest effectiveness of the cost reduction of the department is thus reflected in the X-ray procedures.

For CT, the films utilized are 908 for 519 procedures for March. It is 843 for 709 procedures in April and 605 for 690 procedures in May.

Thus the effectiveness for the cost-cutting increased gradually from March to May. The least number of films are utilized in May which is also the most cost-effective month of the period. The department was successful in bringing down the cost of the films in this period.

For MRI, the film utilization is 933 for 402 i.e. average of 2.32 films per study; for March, 647 for 272 i.e. average of 2.37 per study in April. It is 560 for 274 in May i.e. an average of 2.04 films per study.

Benchmarking

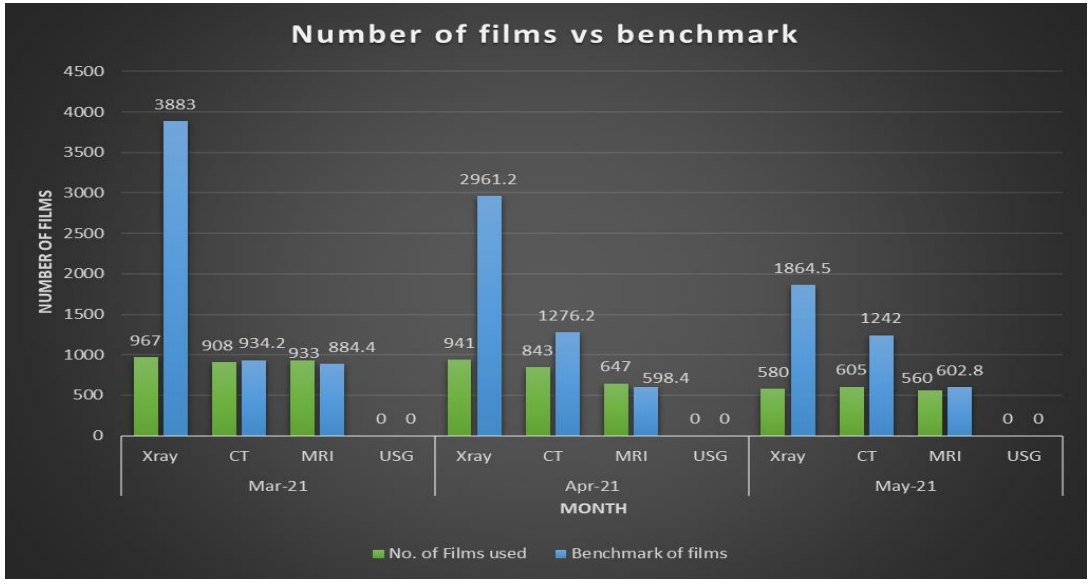


Figure 4.9 Benchmarking of films

The cost reduction techniques of the department are consistent with the quality tools such as benchmarking. Benchmarking supports the operational management and strategic planning of the organization. Benchmarking offers a way to bring into context the department's workload and the pattern of work. It is essential for dealing with the internal pressures of the organization to boost efficiency with the increased demand for radiology services. The use of expensive equipment such as CT, MRI, and X-rays contributes to the rising cost of healthcare. Thus benchmarking is done to control the cost of the department as well as to not compromise with the quality of the services offered by the department. The benchmarking is a tool for continuous quality improvement and thus must be monitored effectively.

The benchmarks of the department are monitored monthly. Benchmarking is focused on productivity and efficiency to make comparisons quantitatively. This technique is used extensively in health services and identifies best practices to aspire in the organization.

As a result of the cost reduction techniques in the hospital, the number of films utilized in the X-ray procedures falls far below the benchmark, For March, the number of films utilized is 967 as compared to the benchmark of 3883 films. In Apr, the number of films utilized is 941 as compared to the benchmark of 2691.2. In May, it is 580 as compared to the benchmark of 1864.5. The benchmark for X-Ray films is 1.1 per study.

For the CT studies, the number of films used is 908 compared to the benchmark of 934.2, in April the films used are 843 as compared to the benchmark of 1276.2 and 605 against the benchmark of 1242. The benchmark for CT films is 1.8 per study.

For MRI studies, the number of films used exceeds the benchmark in March and April. In March, the total number of films used is 933 as compared to the benchmark of 884.4 and in April the number of films used is 647 against the benchmark of 598.4. In May, the films used are 560 against the benchmark of 602.8. The benchmark for MRI films is 2.2 per study.

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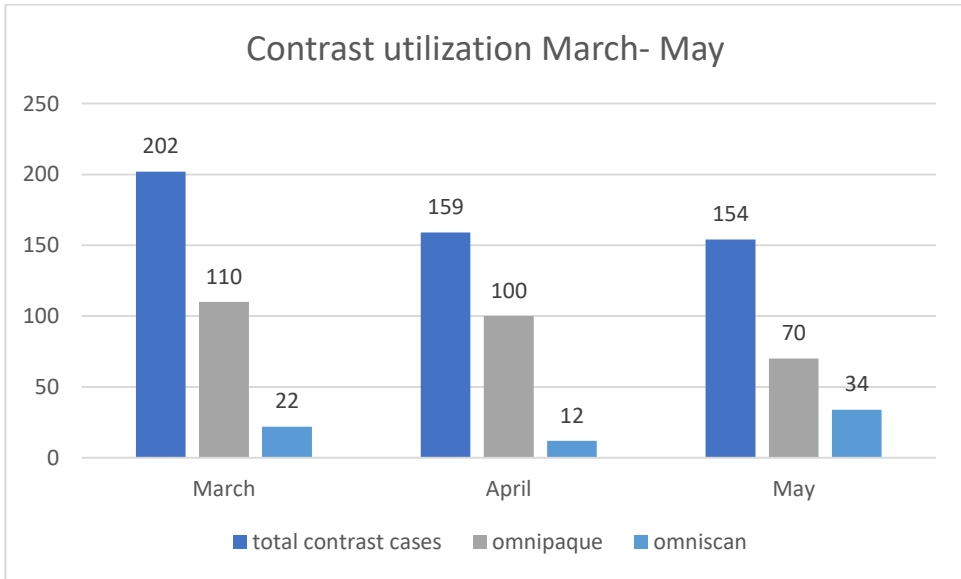

Figure 4.10 Contrast utilization

The contrast studies are variable. The studies depend on the type of investigation ordered by the physicians. The contrast is used judicially by the department. No wastage of contrast is reported during the study period.

Focus is on conducting more studies with less amount contrast which in turn reduces the cost of the item.

The contrast used is of 2 types:

1. Omnipaque
2. Omniscan

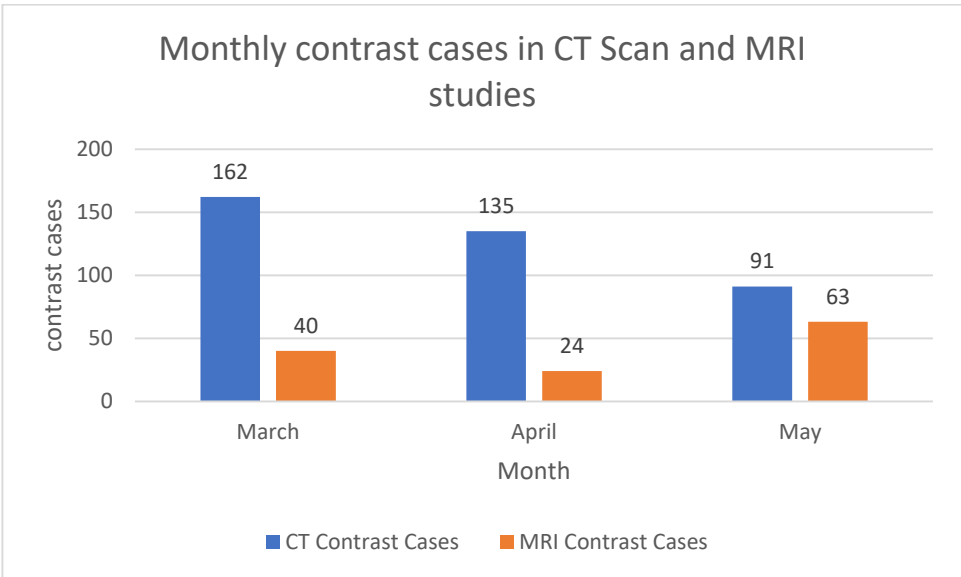

Figure 4.11 Monthly contrast cases

The contrast cases for CT scans are 162 which comprises 80.19% and the remaining 19.80% are for MRI studies in March. In April, the contrast CT cases are 84.90% and 15.09% are MRI contrast cases. The contrast cases differ in the month of May, with 59.09% of CT contrast cases and 40.90% MRI contrast cases.

Thus, the number of contrast cases is variable, and also the cost associated with the contrast also fluctuates.

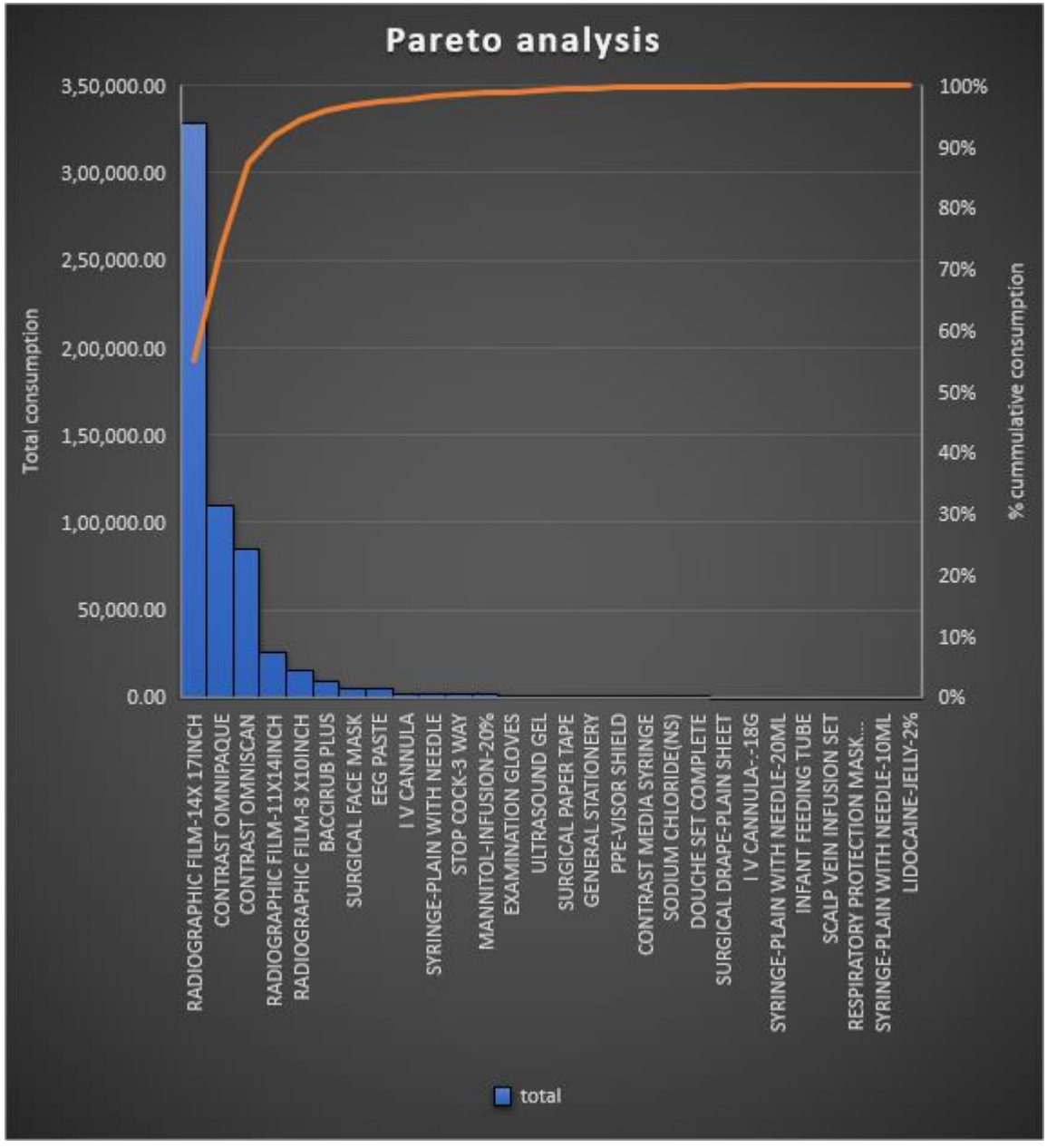

Figure 4.12 Pareto Analysis

Item name	Total cost	Cumulative consumption	% Consumption
RADIOGRAPHIC FILM-14X 17INCH	3,28,608.28	3,28,608.28	54.90
CONTRAST OMNIPAQUE	1,09,970.84	4,38,579.12	73.27
CONTRAST OMNISCAN	84,923.90	5,23,503.02	87.45
RADIOGRAPHIC FILM-11X14INCH	25,741.09	5,49,244.11	91.76
RADIOGRAPHIC FILM-8 X10INCH	15,325.48	5,64,569.59	94.32
BACCIRUB PLUS	9,374.28	5,73,943.87	95.88
SURGICAL FACE MASK	4,898.10	5,78,841.98	96.70
EEG PASTE	4,525.00	5,83,366.98	97.46
IV CANNULA	2,157.34	5,85,524.33	97.82
SYRINGE-PLAIN WITH NEEDLE	2,016.68	5,87,541.00	98.15
STOP COCK-3 WAY	1,959.91	5,89,500.91	98.48
MANNITOL-INFUSION-20%	1,890.00	5,91,390.91	98.80
EXAMINATION GLOVES	1,271.20	5,92,662.11	99.01
ULTRASOUND GEL	1,239.00	5,93,901.11	99.22

SURGICAL PAPER TAPE	1,138.24	5,95,039.36	99.41
GENERAL STATIONERY	826.70	5,95,866.06	99.54
PPE-VISOR SHIELD	551.39	5,96,417.45	99.64
CONTRAST MEDIA SYRINGE	532.00	5,96,949.45	99.72
SODIUM CHLORIDE(NS)	528.53	5,97,477.98	99.81
DOUCHE SET COMPLETE	268.80	5,97,746.78	99.86
SURGICAL DRAPE-PLAIN SHEET	212.80	5,97,959.58	99.89
IV CANNULA-.-18G	197.12	5,98,156.70	99.93
SYRINGE-PLAIN WITH NEEDLE-20ML	185.47	5,98,342.17	99.96
INFANT FEEDING TUBE	58.32	5,98,400.49	99.97
SCALP VEIN INFUSION SET	53.09	5,98,453.58	99.98
RESPIRATORY PROTECTION MASK N95	52.19	5,98,505.77	99.98
SYRINGE-PLAIN WITH NEEDLE-10ML	52.19	5,98,557.96	99.99
LIDOCAINE-JELLY-2%	40.32	5,98,598.28	100.00

Table 4.2 Materials cost and consumption %

Pareto diagrams are bar charts that are used to quantify data and depict the cost, frequency, or period. Here, the Pareto chart is used to depict the cost of various items consumed by the radiology department during 3 months.

In the Pareto analysis, the materials are arranged in a descending manner with the highest value acquiring the top and lowest value at the bottom. The factors contributing the most to the particular effect ie the cost are displayed and visual analysis is done.

Material Name	Total Issue Value	Consumption %	Cumulative consumption %
A Category	438579.118	73.2676875	73.267687
B Category	110664.995	18.4873559	91.755043
C Category	49354.17	8.24495684	100
	598598.282		

Table 4.3 ABC Analysis

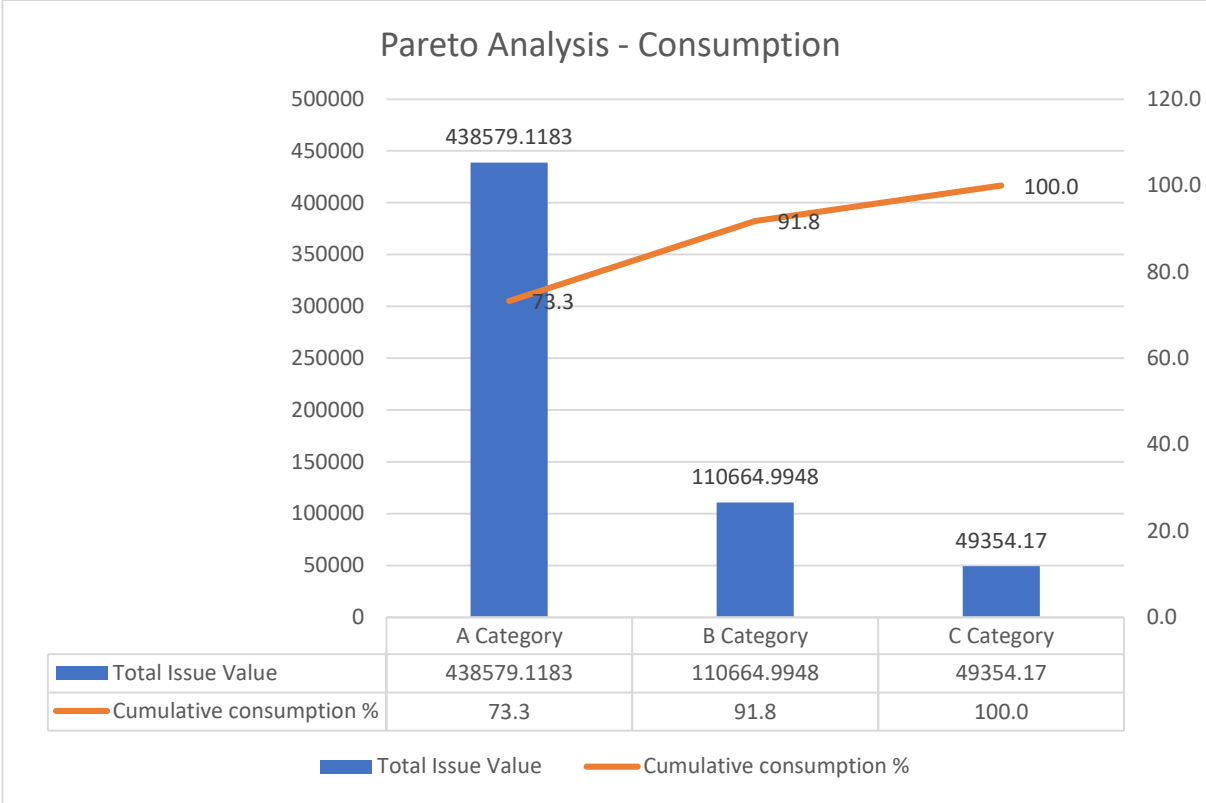

Figure 4.13 Pareto Analysis - Consumption

The Pareto analysis follows an 80/20 rule. It states that 80% of the problems are due to 20% of the causes or 80% of the project returns or benefits are due to 20 % of the work.

It is the business decision-making technique that is used in splitting the number of factors having the greatest influence or impact on an outcome.

The Pareto analysis classifies the number of factors:

The vital few: A small number of factors contributing to most of the problems/project.

The useful many: The remaining large number of factors that contribute to the relatively small part of the project/problem.

In the project context, states that 80% of the cost is attributed to 20 % of items of consumption.

In the hospital, the material consist of 73.3% of the cost is radiographic film-.-14inch x 17inch-x ray dry imaging and Contrast (iohexol)-350mg 100ml-omnipaque gel. These items are categorized in the A category.

The material consisting of 16% of cost are contrast (gadodiamide)-0.5mmol/ml(20ml)-omniscan and Radiographic film- 11inch x 14inch-x-ray di hl dry imaging. These items are categorized in the B category.

The remaining 24 items are classified into the C category. These items comprise 8 % of the total cost.

The Hospital spends a significant amount of the budget for procuring class A material.

Category A items account for fewer items and the highest costs, which pinpoints the need for strict inventory control to prevent wastage and accumulation of capital in buffer stocks.

Around 35-40% of the budget of healthcare organization budget is spent on procuring and purchasing the material and supplies. Material management requires effective inventory control management. As the resources of the hospital are kept a tight rein on, the appropriate utilization of the resources is necessary. The healthcare executives must be well versed with inventory management techniques as it is a vital aspect of the operations of the hospitals.

Inventory control is essential for procuring the right materials, in the right quantity, at the right time, and the right cost.

Chapter 5. Discussion:

The material consumption consists of 28 items indented for the radiology department during the study period i.e. from March to May.

The contrast cases are variable and also the cost associated with the contrast also varies. The cost of the films is maximum for MRI studies. The requirement of films is more for MRI studies, and hence, the consumption of the films is maximum. The film utilization is 2.32 films per study in March; 2.37 per study in April and 2.04 films per study in May. The benchmark for the films for the MRI studies is achieved in May

The total consumption expenditure is 598598.282 (approx. value). On Pareto analysis, 2 items out of 28 are found to be A, and 24 items are found to be C. The items comprising of A category 73.3% of the cost, B consist of 18.5 %, and items in C category consist of 8.2 % of the total cost.

The management of class A material helps to maintain an annual budget and their availability should be kept in check. Category A materials are expensive and require greater attention. The consumption of these materials, their effect on stock level should be monitored continuously. To reduce the carrying cost, the safety stock of the material should be kept low. The materials should always be in stock whenever required. The maintenance of low safety stock is necessary for the prevention of locking up capital by these items and they require strict control.

The management of class B material help in providing the essential items. They are at the level of less priority still their consumption must be watched with moderate control.

The management of class C material is at the least priority level. Such materials are purchased periodically.

The cost reduction measures of the department in the form of film and contrast utilization are quite effective. The consumption as part of the revenue is average 4.59% in 3 months. The strict measures of control, monthly consumption analysis, and commitment of the staff members are all contributory factors for the reduction in expenditure.

The use of quality improvement methods such as benchmarking is very useful in keeping in check the consumption.

Chapter 6. Recommendations:

The cost reduction practices of the department must follow a holistic approach. The radiologists, technicians, and administration must work as a team for achieving the goals.

The maximum scope for cost reduction in the radiology department lies in the MRI Studies. The adoption of recent strategy of providing CDs for MRI studies, instead of films will reduce the film's utilization for MRI studies, thus saving the cost. To reduce the cost related to stationery and paper consumption, greater attention should be on linking the RIS with NH Care App. With the accessibility of all the reports online on NH Care App, the cost related to printing and stationery will be diminished. Eliminating paper records is another money-saving tactic. The purchase department must be informed of the consumption pattern on a weekly basis.

The contrast (omnipaque and omniscan) is one of the costliest materials consumed by the department. The cost of the contrast needs to be monitored continuously The purchase department must be informed of the consumption pattern every month so that the procurement can be done accordingly.

Negotiating rates with the suppliers and vendors for less rates for the items. Total expenditure must be assessed by vendor and category.

There is a need to brainstorm with the team about the items having different consumption and utilization practices and interviewing staff and doctors to identify the differences.

Chapter 7. Conclusion

It is an indispensable part of a hospital administrator to contain and reduce the cost and operating expenses.

The Narayana Health achieves economies of scale by obtaining lower prices for the equipment and optimum utilization of the infrastructure.

The measures for cost reduction are optimum utilization of contrast and films, digitalization of services, achieving economies of scale, having a centralized buying unit for procurement, maintaining records of patients with insurance, and the use of IT. The low prices of consumables as a part of procurement strategy of the hospital and a strict watch on the consumption pattern of the department is commendable.

REFERENCES:

1. Moodley I & Moodley S. A comparative cost analysis of picture archiving and communications systems (PACS) versus conventional radiology in the private sector. South African Journal of Radiology; 2015. 19 (1). Available from: https://www.researchgate.net/publication/277620011_A_comparative_cost_analysis_of_picture_archiving_and_communications_systems_PACS_versus_conventional_radiology_in_the_private_sector
2. Himme A. Critical success factors of strategic cost reduction. Journal of Management Control; 2012. 23. Available from: https://www.researchgate.net/publication/257338845_Critical_success_factors_of_strategic_cost_reduction
3. Geoffrey RD. Costing in Radiology and Health Care: Rationale, Relativity, Rudiments, and Realities. RSNA Journal;2017. Available from: https://doi.org/10.1148/radiol.2016160749
4. Kadom N, Itri JN, Trofimova A, Otero HJ & Horny M. Cost-effectiveness Analysis: An overview of Key Concepts, Recommendations, Controversies, and Pitfalls. Academic Radiology, 26(4), 534-541; 2019. Available from: https://doi.org/10.1016/j.acra.2018.10.014
5. Rubin GD. Costing in Radiology and Health Care: Rationale, Relativity, Rudiments and Realities. RSNA. Volume 282: Number 2
6. Kruskal JB, Reedy A, Pascal L, Rosen MP, Boiselle PM. Lean Approach to Improving Performance and Efficiency in a Radiology Department. RadioGraphics 2012; 32:573-587. Available from: 10.1148/rg.322115128

7. Cohen R. Lean Methodology in Health Care. CHEST: 2018. 154(6):1448-1454. Available from: https://doi.org/10.1016/j.chest.2018.06.005
8. Marin-Garcia, J.A.; Vidal-Carreras, P.I.; Garcia-Sabater, J.J. The Role of Value Stream Mapping in Healthcare Services: A Scoping Review. Int. J. Environ. Res. Public Health 2021, 18, 951. Available from: https://doi.org/10.3390/ ijerph18030951
9. Lawal et al. Lean management in health care: definition, concepts, methodology and effects reported (systematic review protocol). BiomedCentral 2014. Systematic Reviews 2014 3;103. Available from: doi:10.1186/2046-4053-3-103
10. Birchall D. Benchmarking in radiology: apples and oranges? The British Journal of Radiology. 83 (2010), 1-3. Available from: 10.1259/bjr/31880882
11. YİĞİT V. Medical Materials Inventory Control Analysis at University Hospital in Turkey. Int J Health Sci Res. 2017; 7(1):227-231.
12. Philips MRI Machine Scanner. Indiamart [Internet], [Publisher unknown] Available from: https://dir.indiamart.com/impcat/philips-mri-machine.html
13. Camgöz-Akdağ* H, Beldek T, Konyalıoğlu AK. Process Improvement in a Radiology Department with Value Stream Mapping and its linkage to Industry 4.0. IIOABJ 2018; 9(6):36-41
14. Rose MM. Improving the Supply Process in an Interventional Procedures Unit. Master's Projects 2017: 11. Available from: http://scholarworks.gvsu.edu/kcon_projects/11?utm_source=scholarworks.gvsu.edu%2Fkcon_projects%2F11&utm_medium=PDF&utm_campaign=PDFCoverPages
15. Bucourt M, Busse R, Güttler Felix, Wintzer C, Collettini F, Kloeters F, Hamm B, Teichgräber UK, Lean Manufacturing and Toyota Production System

terminology applied to the procurement of vascular stents in interventional radiology. Insights Imaging 2011; 2;415-423. Available from: DOI 10.1007/s13244-011-0097-0

16. Singh MM et al. Cost containment in hospitals and their effectiveness, importance and use. RFHHA 2017; 1.1-30. Available at ResearchGate: Cost containment in hospitals & their effectiveness, Importance and use (researchgate.net)
17. Lipcamon J. Diagnostic Imaging [Internet]. [Place unknown], [Publisher unknown]; 2015. Available from: https://www.diagnosticimaging.com/view/7-wastes-radiology-department
18. Oeleti A, Thanh O.Unit Purchase Workflow.Nest Portal. Narayana Health