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Application of Lean Methodology in Radiology Department of a Multispecialty Hospital.

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Abstract:

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 study was carried out in a Multispecialty Hospital in India. The objective of the study was to reduce identify wastes or "muda" as in lean methodology of Toyota Production System and to study the cost of materials consumed in the radiology department without compromising the quality of services. The study design was 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) (medical imaging software) was also used. The cost related to radiology was determined for the consumables. The sampling technique was purposive. Data was analysed using Minitab and MS Excel. Value Stream Map was created, and 8 types of wastes (lean tool) were identified in the study. The wastes or "muda" occurred during transportation which occurred during shifting of patients and material transportation, inventory, motion, too many clicks for uploading images, waiting for procedures, waiting for reports, re-do and unnecessary tests, excess radiation doses, reporting errors, and insufficient training to staff. In the MRI procedure, Value Stream Map was made, the takt time of 24 min, but the cycle time was 100 min and waiting of 120 minutes, which resulted in the lead time of 220 minutes. Pareto analysis of the consumables was done for 28 products, the products were classified under ABC categories. Radiographic Film-14 x 17 inch & Contrast Omnipaque consumed 73.3 % of the consumption value, they were classified under A category products, 3 products viz Contrast Omniscan, Radiographic Film-11x14inch, Radiographic Film-8 X10inch were categorized under B category which consumed additional 21.05 % of the expenditure, the remaining 20 products were classified under C category, which consumed only 5.68 % of the monetary consumption value.

Category A materials are the most expensive and hence require strict control. 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.

Some of the strategies for cost reduction could be digitalization of services, use of IT in MRI studies CDs could be provided, linking the RIS with mobile application. The reports could be made assessable online which would reduce paper records. is another money-saving tactic. The purchase department must be informed of the consumption pattern on a weekly or monthly basis, particularly for costly products like contrast (Omnipaque and Omniscan).

Keywords: Radiology, Lean, Toyota Production System, Muda, Consumables, Value Stream Map, Pareto Chart.

Introduction

Radiology is the medical discipline that uses medical imaging to diagnose and treat diseases within the bodies of animals, including humans. It is involved with medical imaging techniques such as X-ray, Ultrasound sonography (USG), Computed tomography (CT), Magnetic Resonance Imaging (MRI) etc. to diagnose and treat diseases. It 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. As the department is important revenue generating area in a hospital, it is key area for reducing the expenditure of the hospital. Hence, hospital administrators are continually looking for ways to reduce the cost and expenditure related to radiology services[1].

The need for containing and controlling the imaging cost requires an understanding of procedures and quantify the cost of the imaging services. Radiology department uses consumables for procedures like X Ray, CT, MRI & USG and may include X-ray film for producing radiographic image and generally consists of emulsion of silver bromide (AgBr), Contrast or dyes like Omnipaque™ (iohexol) by GE Healthcare, which contains iodine and add contrast to body parts, and is taken before imaging tests (such as CT scans), Contrast Omniscan™ which is a Gadolinium based contrast agent used in MRI examination generally for tumours and abnormalities in brain and spine, electroencephalogram (EEG) conducive paste used for brain disorders, and helps in reducing skin impedance while using EEG electrodes, intravenous cannula or IV cannula which is a tube inserted into the body for delivery of fluids into the body, Syringe-plain with needle, 3 way Stop cock for infusion of two fluids, Mannitol 20% Infusion which is a medicine with high osmotic pressure and increases water retention, Examination gloves, Ultrasound Gel which reduces the air between the skin and the probe or transducer, Surgical paper tape, General stationery, personal protective equipment (PPE) face shield for infection control[2], sodium chloride solution (intravenous) normal saline (NS), Surgical drape which is OT linen used to isolate surgical site from other areas of patient body and reduce surgical site infection (SSI), Scalp vein set for drawing blood or for intravenous (I.V.) therapy into a vein, N95 respirator & surgical masks, Syringe-plain with needle, Xylocaine 2% Jelly which contains Lidocaine used for local anesthetics, Baccirub Plus which is Antimicrobial Alcohol Hand Rub, etc. The diverse nature of value and cost of radiology consumables 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.

Lean manufacturing concepts were established in Toyota corporation in Japan in 1970s and 1980s, hence are also called as Toyota Production Systems. The principles of lean include identifying all steps that add value to the product or service through value stream map (VSM), identifying & eliminating wastes, and continual improvement of the processes for improving quality. These tool and techniques are aimed to optimize time, improve productivity, while improving quality of products and services[3]. In Lean approach there are 7 type of wastes or muda as referred in Toyota Production System which are Transportation, Inventory, Motion, Waiting, Overproduction, Overprocessing, Defects. These wastes were defined by Taiichi Ohno, father of the TPS. Some practitioners include 8th waste as Skills or unutilized talent. They make the acronym TIMWOODS.

First application of lean principles in healthcare was in 2001 in Virgina Mason Medical Centre, in Seattle, Washington, when they applied Toyota Production System (TPS) to the healthcare context. They implemented Virginia Mason Production System (VMPS) to identify and eliminate "muda" or waste to improve productivity and efficiency[4].

Value stream mapping in hospitals maps all the operational processes related to patient flow, material supplies, information related to the journey of patients, etc. and acts as a visual tool of the health care service delivery. Takt time is calculated which signifies the time in which a service needs to be completed keeping in mind the demand and total available service time. Current-state and future State Value Stream Map are drawn[5].

Lean techniques could be applied to reduce costs and improve quality in radiology department. The basic tools included "kaizen" which means continuous improvement, VSM(value stream mapping) of the department, applying 5 S's which include Sort, Set in order, Shine, Standardise and Sustain, and other lean productive improvement techniques[6,7,8].

With this backdrop the current study was undertaken to apply lean concepts and explore avenues for cost containment and to identify the wastes (non-value adding steps) in the radiology department for resource utilization.

Materials and Methods

The research was undertaken with the objective to identify wastes using lean approach, and to conduct a cost analysis of the material consumption in the radiology department. It was carried in a Multispecialty tertiary care hospital based in Jaipur, India.

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) (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 analysed using Minitab & MS Excel. 8 type of wastes (TIMWOODS) were identified for the radiology department, current and future state Value Stream Maps were developed, and Pareto analysis of the material consumed in the radiology department was done using Minitab software.

Results & Discussion

Waste (TIMWOODS) analysis of Radiology Department[9,10,11]

In Lean Six Sigma, the type of wastes may include **t**ransportation (i.e. unnecessary movement of people, products and information), **i**nventory, **m**ovement, **w**aiting, **o**ver-production, **o**verprocessing, **d**efective products or services and underutilized **s**kills & inadequate training. They may be memorized with the acronym as "**timwoods**".

The concept was analyzed in the radiology department and all types of wastes were identified[12].

1. **Transportation:** The transportation type of waste took 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 took 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 can also adds to the cost.
2. **Inventory**: 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:** It was identified as too many clicks for loading and uploading the images in the PACS[9].
4. **Waiting:** Waiting was observed as waiting for the procedure i.e. the time between the patient arrived at the counter to the time of the procedure, waiting in report generation i.e. time between examination/procedure and the report finalization by the radiologist, and waiting for receiving the materials from the store.
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 the service which is required. The over-processing in the department occurred due to 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.

The wastes have been depicted in Fig.1 below.

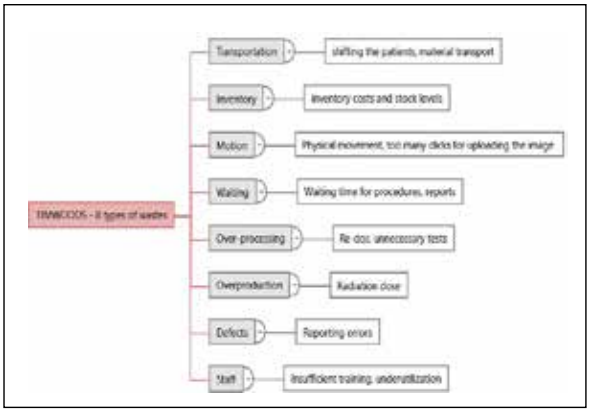

Fig. 1 8: wastes of the Radiology Department

Value Stream Maps of the Radiology procedures[13,14]

The workflow of radiology department for Outpatient (OPD) was recorded which included request for examination, registration at the billing counter, and included collecting history of diseases such as hypertension, diabetes, and cardiac health conditions, allergies to the contrast, surgeries, metallic implants, etc. A consent form was filled for the MRI scan. When the process of registration is completed, the patient was directed to wait for his/her turn. The patient was called for the examination and the patient was 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 could 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.

As there was maximum waiting in the MRI procedure, current and future state Value Stream Map (Lean TOOL) of MRI were created for the same (Figure 2, Figure 3) using Minitab software.

Current State MRI Value Stream Map

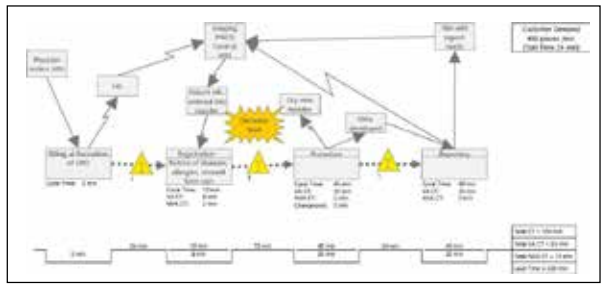

Fig. 2: Value Stream Map (Current State) - MRI

The total no. of procedures in the study month were 400 and timings was 9.00am-5.30pm, daily 6 days / week, which gave the takt time of 24 min. The cycle time was observed at 83 min and Lead time of 220 min.

In the future state map, lean time was reduced to 83 min, as shown in Fig. 3.

Future State Value Stream Map for MRI procedure

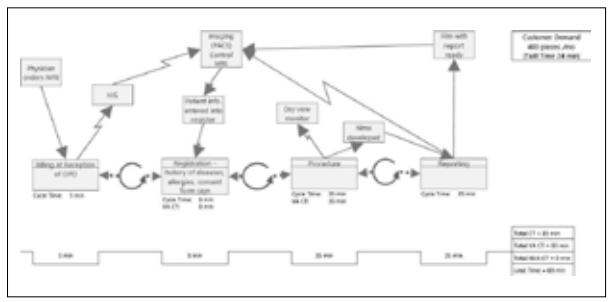

Fig. 3: Value Stream Map (Future State) - MRI

Cost Control of consumables[15]

Radiology department consumables for the procedures (X Ray, CT, MRI & USG) was studied for three months. The consumables included Radiographic films (14x 17Inch, 11x14inch, 8 x10inch), contrast (Omnipaque & Omniscan), Baccirub plus, Surgical face mask, EEG paste, IV cannula, Syringe-plain with needle, Stop cock-3 way, Mannitol-Infusion-20%, Examination gloves, Ultrasound gel, Surgical paper tape, General stationery, PPE-visor shield, Contrast media Syringe, Sodium chloride(NS), Douche set complete, Surgical drape-plain sheet, IV cannula, Syringe-plain with needle, Infant feeding tube, Scalp vein infusion set, Respiratory protection mask N95, Syringe-plain with needle, Lidocaine-jelly-2% etc.

The material consumption consists of 28 items indented for the radiology department during the study period i.e. from March to May 2021. To understand the products which were consuming maximum consumption value, Pareto Chart was developed which is shown in the Figure 4 below.

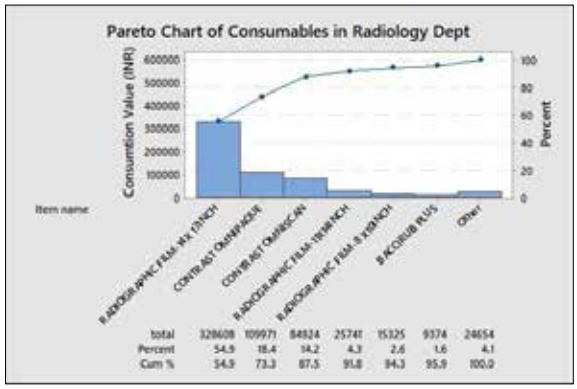

Fig. 4: Pareto Chart for consumables in Radiology Dept.

The total consumption expenditure is 598598.282 (approx. value). In the data analysis, the consumption of 28 consumables were studied (three months). Radiographic Film-14 x 17 inch & Contrast Omnipaque consumed 73.3 % of the consumption value, hence they were classified under A category products, 3 products viz Contrast Omniscan, Radiographic Film-11x14inch, Radiographic Film-8 X10inch were categorized under B category which consumed additional 21.05 % of the expenditure, the remaining 20 products were classified under C category, which consumed only 5.68 % of the monetary consumption value.

Conclusion

The wastes or "muda" occurred during transportation which occurred during shifting of patients and material transportation, inventory, motion, too many clicks for uploading images, waiting for procedures, waiting for reports, re-do and unnecessary tests, excess radiation doses, reporting errors, and insufficient training to staff[16].

In the MRI procedure, Value Stream Map was made, the takt time of 24 min, but the cycle time was 100 min and waiting of 120 minutes, which resulted in the lead time of 220 minutes. Since waiting is waste, so it needs to be reduced as shown in the future state value stream map.

It was observed that consumables Radiographic film-14x 17inch, Contrast Omnipaque, Contrast Omniscan were consuming 87.5% of the monetary value. Hence it was suggested to utilize the film size 14 x 17 inches in X-ray by dividing it into 4 portions, which may help in cost reduction. The contrast used were of 2 types – Omnipaque & Omniscan and consumption was dependent on investigations ordered by the physicians. It was advised to use the contrast judiciously, avoiding any wastage. It was also advised that have tighter inventory control of the above material and supplies (Radiographic film-14x 17inch, Contrast Omnipaque, Contrast Omniscan). As cost reduction practices of the radiology department is holistic approach, the radiologists, technicians, and administration must work as a team for achieving the goals.

Some of the strategies for cost reduction could be digitalization of services, use of IT in MRI studies CDs could be provided, linking the RIS with mobile application. The reports could be made assessable online which would reduce paper records. is another money-saving tactic. The purchase department must be informed of the consumption pattern on a weekly or monthly basis, particularly for costly products like contrast (Omnipaque and Omniscan).

Ethical clearance : Due considerations of confidentiality and privacy of information has been undertaken in this study.

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Conflict of Interest : Nil

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