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CLINICAL & BASIC RESEARCH

Implementing Lean Management Techniques at a Radiation Oncology Department

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تطبيق تقنيات إدارة لين في قسم طب الأورام الإشعاعي

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abstract: ***Objectives:*** Lean management (LM) principles were first developed by a Japanese manufacturing company to maximise value and minimise waste in the automotive industry. However, these principles can also be applied in the healthcare sector. This study aimed to illustrate the process of implementing LM principles in a radiation oncology department to streamline workflow and identify and reduce waste. ***Methods:*** This study took place in the Department of Radiation Oncology, Royal Hospital, Muscat, Oman, in December 2016. A value stream map (VSM) was created for the chain of processes followed in the department. A waste analysis was conducted to determine which processes did not add value for the patient or healthcare provider. ***Results:*** Based on the VSM analysis, only six out of 13 steps were found to be of value. Necessary and unnecessary non-value-adding activities were identified. Sources of waste included parking and registration. In addition, variabilities in workload were noted. ***Conclusion:*** Overall, LM principles improve workflow, reduce waste and enhance patient and staff satisfaction. In the current study, the application of LM principles helped to improve value in a radiation oncology department.

Keywords: Health Services Administration; Healthcare Quality Assurance; Total Quality Management; Organization and Administration; Efficiency; Oman.

الملخص: الهدف: مبادئ إدارة لين تم تطويرها من قبل شركة تصنيع يابانية لتحقيق أقصى قدر من القيمة وتقليل الهدر في صناعة السيارات، وبالإمكان تطبيق هذه المبادئ أيضًا في قطاع الرعاية الصحية، تهدف هذه الدراسة إلى توضيح عملية تطبيق مبادئ إدارة لين في قسم طب الأورام الإشعاعي لتيسير تدفق العمل وتحديد الهدر وتقليله. **الطريقة:** أجريت هذه الدراسة في قسم طب الأورام الإشعاعي بالمستشفى السلطاني في مسقط، عُمان، وذلك خلال شهر ديسمبر 2016، تم إنشاء خريطة تدفق القيمة لسلسلة العمليات المتبعة في القسم، تم بعدها تم إجراء تحليل للهدر لتحديد العمليات التي لم تكن لها أي قيمة إضافية سواءاً للمريض أو للموظف الصحي. **النتائج:** استناداً إلى تحليل خريطة تدفق القيمة، تم العثور على ستة خطوات فقط من أصل 13 خطوة والتي كانت ذات قيمة. تم كذلك تحديد الأنشطة الضرورية وغير الضرورية التي لم تكن لها أي قيمة مضافة، شملت مصادر الهدر مواقف السيارات وعمليات التسجيل، بالإضافة إلى ذلك، لوحظت تفاوت في أعباء العمل. **الخلاصة:** بشكل عام، تعمل مبادئ إدارة لين على تحسين سير العمل وتقليل الهدر إضافة إلى تعزيز مدى الرضا لدى المرضى والموظفين، وقد ساعد تطبيق مبادئ إدارة لين على تعزيز القيمة في قسم طب الأورام الإشعاعي.

الكلمات المفتاحية: إدارة الخدمات الصحية؛ ضمان جودة الرعاية الصحية؛ إدارة الجودة الشاملة؛ التنظيم والإدارة؛ نجاعة؛ عمان.

Advances in Knowledge

- *This study delineates the steps involved to apply lean management principles at a radiation oncology department in order to streamline work flow and reduce waste.*

Application to Patient Care

- *In the healthcare sector, lean management principles can help to increase patient satisfaction by increasing value (e.g. timely treatment delivery, reduced waiting time, etc.) and reducing wasteful activities and processes.*

Lean management (LM) principles were first developed to improve production and increase customer satisfaction in the automotive industry by the Toyota company (Toyota Motor Corp, Aichi Prefecture, Japan).[1] Since then, LM principles have been widely applied in various sectors with tremendous success, including in healthcare delivery.[2–4] The aim of LM tools and techniques is to organise processes, leading to increased value which manifests as increased customer satisfaction and the elimination of waste.[5,6] However, LM principles are not designed as a set of regulations and rules to be applied at a certain stage; instead, the aim is the continuous improvement of existing processes.[7]

One specific LM tool is the creation of a value stream map (VSM). This technique involves the identification of the chain of processes involved in the creation and distribution of a product or a service, thus helping personnel to detect inefficiencies, work load variability or non-value-adding (NVA) activities that lead to increased

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Table 1: Categories of waste according to lean management principles[4]

Category	Definition
Transportation	Unnecessary transportation of a product through a system
Inventory	Unnecessary storage of a product
Motion	Non-productive motion that adds no value to the patient or healthcare provider
Waiting	Unnecessary waiting for the next event/step in the process
Overproduction	Overproduction of supplies
Overprocessing	Overprocessing in which more value than necessary is added to the product
Defects	Defects in equipment/processes
Intellect/skills	Steps/actions which do not utilise the full intellectual capacity or skills of the employees

waste.[8–10] It is an integral instrument used in LM interventions to assist in delineating the steps which would help an organisation to reach its goals. However, a VSM is quite different from other flowcharts in that it incorporates both materials and information.[9]

In healthcare, LM is defined as "an organization's cultural commitment to applying the scientific method to designing, performing and continuously improving the work delivered by teams of people, leading to measurably better value for patients and other stakeholders".[11] The focus is on the movement of the patient through the system, rather than individual interactions between patients and healthcare providers.[12] In healthcare facilities, LM techniques have been documented to reduce costs, errors and time wastage as well as improve patient and staff satisfaction.[7,9] Moreover, one hospital in the USA reported that LM techniques resulted in the timely initiation of 99% of its operations, while another managed to reduce inpatient total care costs by 25% and improve patient satisfaction by almost 100%.[11]

Prior to the delivery of radiotherapy treatment, multiple important steps must be completed; however, any initial setbacks or wastage is reflected in subsequent steps, resulting in treatment delays and decreased patient satisfaction. The Royal Hospital is a tertiary care centre in Muscat, Oman, and is the only centre in the country to offer radiotherapy. In December 2016, one of the hospital's two radiotherapy treatment units was shut down while a new radiotherapy machine was being commissioned. This resulted in a greater patient load at the remaining unit, thereby obligating staff to work harder to ensure that there were no unnecessary delays in treatment. Based on previous research, LM implementation was deemed an appropriate measure to help enable a smoother transition during this period.[9,11] This study was therefore undertaken to delineate the process of implementing LM principles to improve workflow and identify and eliminate sources of waste in the context of radiotherapy treatment.

Methods

This study was conducted in the Department of Radiation Oncology at the Royal Hospital in December 2016. A value stream map (VSM) was developed to document all the steps being undertaken prior to the patient receiving treatment. Subsequently, the VSM was analysed using the '3MUs' tool to detect *muda* (activities with no value), *mura* (unbalanced workload) and *muri* (the overburdening of staff and processes). Of the activities which were designated NVA, the researchers sought to determine whether these were nonessential or necessary as well as those which constituted sources of waste. Finally, *heijunka*, another LM tool, was utilised to level workload. Other LM tools were either not applicable to the department or it would have been too early to implement them.

For the purposes of the study, value was defined as achieving patient satisfaction through the timely delivery of treatment. Sources of waste were identified in eight categories, consisting of transportation, inventory, motion, waiting, overproduction, overprocessing, defects and intellect/skills [Table 1].[6] Prior to the implementation of LM principles, all personnel affiliated with the department participated in a series of continuing medical education activities to introduce underlying LM concepts and how to implement these principles effectively.

The VSM was constructed using ConceptDraw OFFICE software, Version 11 (Computer Systems Odessa, Odessa, Ukraine). Radiation oncologists, medical physicists, dosimetrists, radiotherapy technologists and oncology nurses all helped in formulating and editing the VSM. The VSM started from the moment the patient first arrived at the hospital's parking lot for their first clinical appointment and ended with the conclusion of treatment.

This study was approved by the Centre of Studies & Research at the Ministry of Health in Oman (SRC #4/2018). Informed consent was not deemed necessary as there were no direct encounters with patients. Furthermore, no information was obtained from electronic patient records during the course of this study.

Results

A VSM was constructed to delineate the steps involved in the provision of radiotherapy treatment at the Royal Hospital [Figure 1]. After analysing the VSM, six out

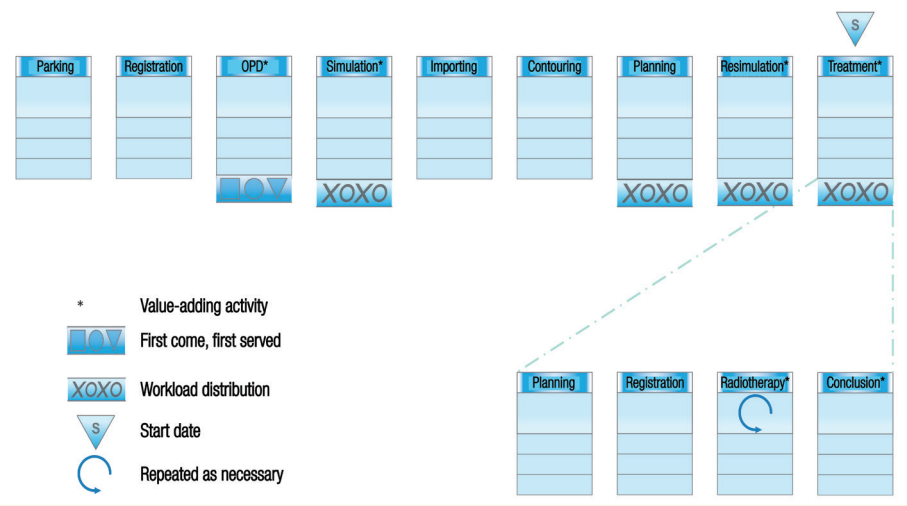

Figure 1: Value stream map for the chain of processes followed at the Department of Radiation Oncology at the Royal Hospital, Muscat, Oman.
OPD = outpatient department.

Table 2: Procedural steps and their value for the chain of processes followed at the Department of Radiation Oncology at the Royal Hospital, Muscat, Oman

	Step	Details	Role	Value
1	Parking	Time spent by the patient to secure a parking space	Patient	Waste-generating/ necessary NVA
2	Registration	Time taken for the patient to register at the hospital	Patient	Waste-generating/ necessary NVA
3	OPD	Time spent during the first visit to determine indication for and doses of radiation	Physician	Value-adding
4	Simulation	Duration of radiotherapy simulation	Radiotherapist	Value-adding
5	Importing	Duration of importing simulation images to the medical physics department	Medical physicist	Necessary NVA
6	Contouring	Determining target planning volumes	Physician	Necessary NVA
7	Planning	Calculating patient dosage	Medical physicist	Necessary NVA
8	Re-simulation	Duration of radiotherapy re-simulation	Radiotherapist	Value-adding
9	Treatment	Inclusive of steps 10 to 13	-	Value-adding
10	Parking	Time spent by the patient to secure a parking space	Patient	Waste-generating/ necessary NVA
11	Registration	Time taken for the patient to register at the hospital	Patient	Waste-generating/ necessary NVA
12	Radiotherapy	Duration of radiotherapy sessions	Radiotherapist	Value-adding
13	Conclusion	Final radiotherapy session, including provision of a treatment summary	Physician	Value-adding

NVA = no-value-adding; OPD = outpatient department.

of 13 steps were deemed value-adding. These constituted the patient's first visit to the outpatient department, simulation, re-simulation, treatment, the actual radiotherapy sessions and the conclusion of treatment. Steps which did not add value, but which did not involve the patient's presence at the hospital, included importing, contouring and planning. Parking and registration were waste generating steps that were deemed necessary NVA activities [Table 2].

Parking was deemed a source of waste in the waiting category. However, no intervention to reduce parking-related waste was possible as the designated parking lot for radiotherapy patients was also being utilised by other hospital visitors; furthermore, any intervention

required approval by the hospital administration. Registration was also identified as a source of waste in the transportation, waiting and overproduction categories. In order to register, the patients had to go to the main hospital building and wait alongside outpatients attending other departments. Additionally, the patients had to bring separate appointment slips at every visit for the duration of their treatment, which usually spanned a few weeks. This was solved by introducing a registration desk in the department itself and providing patients with appointment charts that included the dates of each appointment.

The simulation step was also identified to constitute a potential source of intellectual waste. This was because of variations in patient load; on some days, the radiation oncologists sent a large number of patients for simulation while, on other days, there were no patients at all. This problem was solved by abandoning the 'push' system of appointments and implementing a 'pull' system instead. This involved picking a treatment start date slot in the clinic, with the simulation technicians authorised to create simulation appointment slots. Furthermore, medical physicists were encouraged to prioritise cases based on a thorough discussion with the concerned physician, instead of on a 'first come, first served' basis. Finally, a two-shift system was introduced in order to reduce the intellect waste caused by having an excessive number of employees working at the same time.

Discussion

During the study period, the Department of Radiation Oncology at the Royal Hospital was undergoing a period of transition as one of two treatment machines was being decommissioned to facilitate the commission and installation of a new one. This transition created a great deal of stress within the department, with staff anticipating severe treatment delays and patient dissatisfaction. Hence, the current study was conducted to implement LM principles so as to improve efficiency and reduce unnecessary waste, thereby enhancing workflow and, ultimately, ensuring the delivery of treatment in a timely manner.[9,11]

Prior to the application of LM techniques, the department utilised a 'push' system to book appointments for simulation. The radiation oncologist, as the individual who first saw the patient and decided to administer radiation therapy, would book the patient in for simulation, thus 'pushing' the patient through the system. During times when multiple cases presented simultaneously, all of the patients would be sent for simulation at the same time, placing unnecessary pressure on the simulation staff to finish each case as soon as possible so as not to delay treatment. However, on other days, the radiation oncologist would not send any patients for simulation and the staff would not have any work to do, leading to intellectual waste. This practice resulted in *mura* (an unbalanced workload) as well as *muri* (overpressuring of staff). The simulation step itself was therefore seen as a *muda* (source of waste); this can also be extrapolated to subsequent steps in the treatment chain.

In contrast, a 'pull' approach was a simple solution wherein the physician could decide on a treatment start date based on available treatment slots. The term 'pull' indicates that, as all other steps were initiated after the prescribed start date, every event in the chain of events was 'pulled' towards that date. This new appointment system ensured that treatment slots were not available during a particular period if a pre-set number of patients was exceeded, ensuring that patient load would not exceed staff capacity at any stage. The workload therefore became completely predictable, with the fluctuations previously observed in the number of patients greatly reduced. Hence, *heijunka* (levelling of the workload) was achieved, eliminating *mura* and *muri*.

Several interventions helped to reduce waste in the transportation, inventory and intellectual/skills categories. These involved the introduction of a registration desk in the treatment unit, eliminating the need for patients to go to the registration desk at the entrance of the hospital and then return to the radiotherapy treatment unit, as well as the provision of an appointment chart, which helped reduce the overuse of registration slips. Additionally, a two-shift system was introduced in order to reduce intellect waste caused by having more employees than required during working hours due to the presence of only one treatment unit. Finally, cases were prioritised according to those who needed to undergo treatment first rather than on a 'first come, first served' basis.

Currently, three more LM-related projects have been initiated at the Royal Hospital to improve the efficiency of radiotherapy delivery and sustain current improvements. The authors hope that the results of this study inspire other healthcare researchers to seek solutions to waste and escalating costs of care by applying LM principles. However, it should be noted that LM principles are not temporary solutions to address acute issues arising in a department. Fundamentally, LM involves a long-term cultural shift that needs to be adopted by all personnel in a particular setting in order to be effective and produce positive results.[1,6] Overall, LM interventions should form part of a continuous cycle of quality improvement with no set endpoint.

The current study was subject to certain limitations. First, a survey to assess patients and staff satisfaction was not conducted; this would have been a valuable tool to assess the increase in value and reduction in waste

as a result of applying LM principles. Additionally, the survey could have highlighted areas of staff overwork potentially arising as a result of introducing LM interventions. Second, the data were not statistically analysed in terms of the timeliness of treatment delivery, which is the ultimate goal. Further observational studies are therefore needed to evaluate the effect of implementing the abovementioned techniques. The Department of Radiation Oncology is currently working on integrating LM principles within the electronic hospital software. This will allow personnel to record the exact time taken to complete each step of the treatment delivery process.

Conclusion

Applying LM principles is a promising technique to identify sources of waste and streamline workflow in healthcare delivery. Although not all sources of waste were completely eliminated in the current study, they were reduced following the implementation of LM principles; in addition, these principles also enabled a smoother transition process from two treatment units to a single one by improving workflow and workload predictability.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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