Case Study Regarding the Implementation of Lean Management Methods in Healthcare

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Abstract - Lean Management is a well-known applied tool, used to optimize processes and increase value creation. Soon after proving its results in production, Lean Management started to be introduced in different other areas: IT, commerce, education, HR, finance, construction and so on. With the increase of world population and average life time expectation, an expanding interest is focused nowadays on healthcare; the introduction of Lean Management methods proved incredible benefits in the process efficiency and cost savings. In the paper is presented a case study for introducing the Lean management methods in a pathological anatomy laboratory, with the aim to streamline activities and processes during an 11 week project and the capability to extend this type of implementation to other departments and for robotic assisted rehabilitation. This work describes the project steps and highlights the effects of the implementation.
Keywords – Lean Management; Healthcare; Continuous improvement; Laboratory; 5S method, Robotic assisted.

I. INTRODUCTION

Lean management is a process improvement methodology systemized on the Toyota Production System (TPS) that focuses on reducing waste and increasing benefits [1]. Lean emphasizes an array of tools and methods to aid managers and workers in improvement, each designed for specific types of problems to illuminate and remove sources of waste through systems redesign [2, 3]. Some of these tools and methods are: Just in Time, Kanban, Pull, Value Stream Mapping (VS), Visual Management, 5S method, work standardization and so on. There are 8 types of wastes which Lean aims to reduce: Defects, Inventory, Motion, Transport, Waiting, Over-processing, Overproduction, and Talent.

As it was defined in automotive field, Lean Management started soon to be introduced in other manufacturing sectors. Manufacturing companies needed to be able to quickly adapt to new market conditions and remain competitive in meeting changing customer requirements [4], [5], [6], and Lean Management was the appropriate concept to help reach this objectives. Proving improved results, managers searched for ways of adapting the philosophy in services too and this way Lean management started to be implemented in IT, Education, Healthcare, public and professional services.

The application of Lean Philosophy in a healthcare environment is still a relatively new field of research [7]. Lean Thinking in healthcare demonstrates the potential for positive impacts on productivity, cost, quality and timeliness of services provided to the public [8], and USA appears to be the leading country on the number of applications [9].

II. CASE STUDY: INTRODUCING LEAN METHODS IN ROMANIAN HEALTHCARE

2.1 Main aspects

Healthcare is a field where efficiency and efficacy are extremely important as any deviation may lead to serious consequences. In Romania, as in many other countries, Lean Management in healthcare is unknown and therefore unexplored field in spite of its huge potential.

In the conducted empirical research was implemented the Lean management philosophy in a pathological anatomy laboratory situated in Romania, having more than 20 employees: doctors, nurses, autopsies, recorders, and caregivers, the project aim being to streamline activities and processes during an 11 week project.

The project started with a brainstorming discussion with the Laboratory top management in order to reveal and understand the internal problems and the optimisation needs. Site visits and team meetings lead to the process understanding and the process specificities. The first stage follow the specific conceptual model destined to the implementation of the Lean management methods, as illustrated in figure 1.

Figure 1 PTDC model to introduce Lean Management Methods [10]

2.2 Step 1. Planning

A good planning is one of the most important steps in any project; the impact of different actions must be well determined, later correction cost could be disastrous for the project success. Planning is crucial in determining the success or failure, for the Planning step we pointed the vision, scope, objectives, challenges and strategy of the Pathological Anatomy Laboratory (PAL), identifying the actual situation accordingly to the defined vision and establishing some short-term objectives accordingly to the long-term objectives.

The main scope of the project by applying the Lean management within the PAL is to optimize the samples processing times, obtaining a shorter average time of the issued results at the PAL level. For reaching the scope, a deeper view of the process was needed, so a Value Stream Mapping was elaborated (Figure 2). This tool helps to identify the main phases of the process and to classify them into: transport, control, value-adding or non-value-adding activities.

For a more complete image of the actual situation, data regarding the number and the receiving patterns of the samples were collected, processed and analyzed. The results showed that the average number of the collected samples follows some yearly cyclicality, for the same considered month: March and November, repeatedly have higher average of the number of collected samples per day.

One of the first analysis conclusion was to start with 5S Method – as the first method to introduce when is started the Lean management PAT (Process Analytical Technology - the Framework for Innovative Pharmaceutical Development, Manufacturing, and Quality Assurance), considering in the first lane the need to find the major wastes to eliminate before changing anything in the structural behaviour of the unit.

2.3 Step 2. Training

The second step consisted in organizing training for employees. People in medical environment are not familiarized with Lean management terminology and philosophy. In Step 2 was necessary to adapt the training to the medical field, and to the specialized medical staff focused on the introduction into the Lean management methods and principles, and more specifically into the 5S method. The training was scheduled in parallel with the regular activity so we reach an average successful participation of 87,5% of the employees. The results was the assimilation of knowledge regarding the main Lean management tools mean Value, Waste and Flow and the 8 types of wastes with concrete examples from the healthcare industry.

Figure 2 PAL Value Stream Mapping

2.4 Step 3. Development

It is a complex and laborious step, consisting in the implementation of the DMAIC (Define-Measure-Analyze-Improve-Control) approach in the Pathological Anatomy Laboratory. The prerogatives for a successful implementation were assured: the planning was done and the people were trained. Specific tools were proposed for each of the 5 DMAIC stages that facilitate the implementation. In order to Define sub-stages, 3 important documents were elaborated:

1. Project Charter - an instrument that helps to define the problem, the objectives, the implementation team, deadlines and so on.
2. The Voice of the Client - a tool which helped to define who the client is, what his needs and requirements are.

We elaborated a list of the comments received from the clients, after which we have transformed them into specific requirements.

3. The SIPOC diagram, which represents a map of the process at a high level, which allowed the team to see the process in relation to its inputs and outputs.

The Project Charter, developed together with PAL's management is described in the table 1.

Table -1 Project Charter

Problem	Objective	Scope	Measurements
The samples are processed in about 4 days. It is desired to optimize the processing times of the samples, especially for the sectioning operation, where the times are not limited by the capacity of the machines and work equipment, but which can delay the process.	Reducing the sectioning time of paraffin blocks by 10%	Reducing the sectioning time of paraffin blocks. Performing sectioning in the first hours and in reduced time, we get reduce the processing time of the samples, allow the re-sectioning, serial sectioning and special colorings to be carried out in good time.	No.. samples / day; Time / sectioning operation
Deadline	Deliverables	Levers	Team
Define: week 7; Measure: week 7,8; Analyze: week 8; Improve: week 9-15; Control: week 16,17.	Implementation plan; Work instructions; Communication panel (visual management).	Exterior: Other units of the hospital; Interior: experience and existing records.	Facilitators (external team); Service Management; Chief Assistant; Technicians.

The sub-stage of Measure followed: the selected parameters to be measured, data collection was planned and conducted. The collected data was analyzed. First we analyzed the data before the implementation of the project using Boxplot tool, with Minitab 18. The results (please see figure 3) showed significant deviation between operators and big variations for 4 of them (BG, GA, PC and VM).

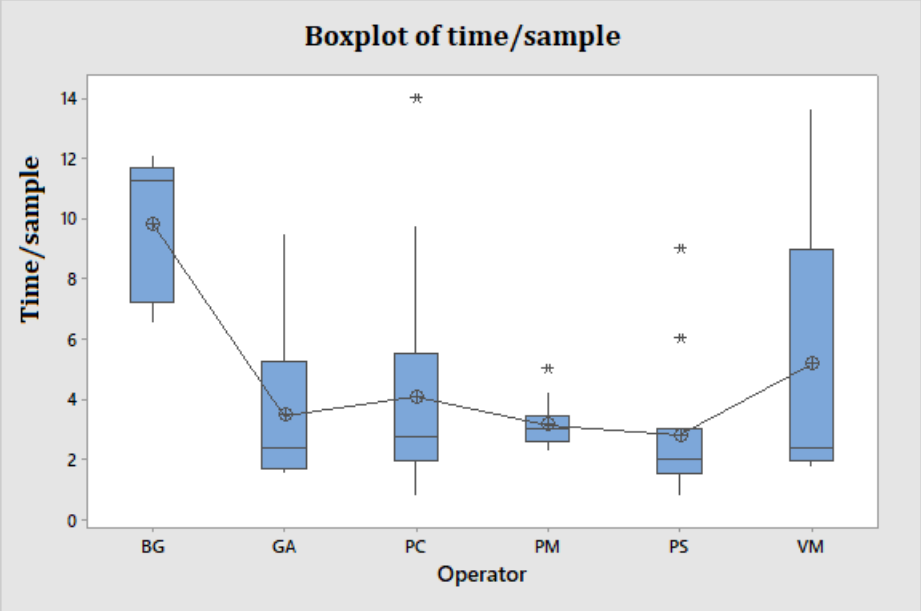

Figure 3 Boxplot tool for analyzing the time/sample for each operator before the implementation

Then was stepped up in a deeper analysis of the ongoing process, based on the VSM, subsequently, the 5 "Why?" method was used to identify the root cause of the deviations. We found out that some procedures need to be examined and reinforced.

In the Improve sub-stage was used the visual management tools, the 5S Method and the principles of continuous improvement. At this stage a first set of proposals was elaborated, many of them were accepted and implemented, useful records have been introduced to optimize the data collection and facilitate analyses.

After introducing 5S methods, started the display of the employees' results on a TV screen. Result: in the first 2 months, as expected, people opposed the change; after, due to the PAL management perseverance, employees accepted the change and starts to adapt to the new rules. As a result, we remarked an impressively improved by 24,4% of the average productivity in only 7 months for one of the main phases of the process: slicing the samples.

In the sub-stage Control, was elaborated a Control plan, a Monitoring and a Response plan, and the whole project was documented, audits were introduced and the monthly results were displayed in a transparent manner. As well, was developed a 5S checklist, adapted to the Laboratory's specificity, needed for 5S audit.

2.5 Step 4. Coaching

The last step consisted in ensuring all the needed support for the PAL management and the PAL team. In this way the PAL management was helped to sustain the improvements. By the end of the project, the internal implementation team was able to individually manage small projects. As an external team, we continue to give support until the "continuous improvement" will become a second nature of the Pathological Anatomy Service.

III. RESULTS AND EFFECTS OF THE IMPLEMENTATION

The project was implemented in an 11 weeks intensive activity, but the Support activities continue until today.

One of the main quantifiable results is the productivity per time unit of operators in the Sectioning operation. In the figure 4 can be noticed not only the reduction of the operators average time, but also the decrease of the big deviation that was between the team members before the implementation. Furthermore, the team average decreased by 24,4% in 7 months.

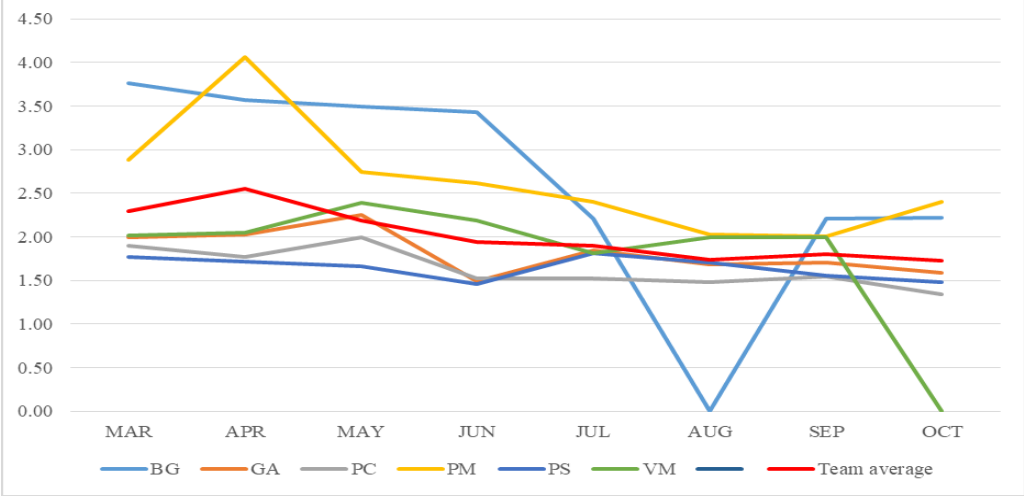

Figure 4. Evolution of average time per sample for operators and for the team, in minutes

During the project, the results were improved, changes were made and new procedures were introduced. The purpose of the project was achieved by new: streamlined processes, organized activities and introduced standards;
Other important achievements and results of the project are:
Elaboration of the process map;
Introduction of working procedures;
Increasing the degree of employee responsibility;
Analysis of the general evolution of the number of samples;
Reorganization of the cleaning room and the changing room.
Elaboration of records and introduction of electronic registers;
Analysis of the individual evolution of operators in the sectioning phase;
Elaboration of DMAIC documents: Project Charter, SIPOC, Voice of the client;
Awareness of the concepts of "waste", "value" and identification of their associated activities;
Elaboration of a complete map of the functional circuits (of samples, waste, personnel and documents);
Introduction of monthly records: no. of samples per day, average time / sample for each operator, number of samples / operator;
Raising awareness among employees of the importance of the cleanliness and discipline efficiency in the workplace and empowering the involved personnel;
Introducing the 5S standard and audit its compliance. The application of the 5S method has led to the following improvements: eliminating unnecessary objects from the workplace, reducing risks, ordering work desks, reducing exposed objects, organizing the warehouse, easier cleaning, clarity, order, professionalism, efficient use of furniture, focus on the essentials, simplification, increased concentration, time savings, neat appearance, generation of free space, use of visual management, labeling of shelves, standardization, "a place for everything and everything in its place".

VI. PRELIMINARY ESSAYS AND NEW OPENINGS FOR LEAN MANAGEMENT IN HEALTHCARE APPLICATIONS

For the Pathological Anatomy Service team, the project generated a significant percentage of know-how. The good example was disseminated that raise a new potential demand from different departments. The most interested seems to be the departments that see already immediate effects and improvements like the Pharmaceutical and drugs distribution department and the Pulmonology department were the material and patients fluxes plays an important role, also considering the multi-standards approach within the regular internal medicine activity, or in the case of emergency and intensive care, or for the patients who need life support and mechanical ventilation.
Different from the actual situation but planned on long term we have to consider the increase of world population in urban areas and the increase of the average life time expectation in the entire EU area. The major impact and response of these two trends is the costs increase on one hand and on the other hand the need of using robotic systems in many of the healthcare applications.
In this new scenario the Lean Management is not coming to optimize the activities and to reduce and/or eliminate the wastes within different processes, within a change management approach. In this sense the Lean Management

procedures can be planned and implemented from the beginning along with the investment and the implementation in robotic assisted solutions. This thinking indicates that the accumulated know-how can be used and expand also for other sections and departments of Hospitals and Cliniques. From the considered studies this Know-how may include the:
Standardization of the health care process;
Increasing the productive efficiency of the employees;
Methods of continuous improvement of the healthcare industry process;
Accumulation of advanced knowledge regarding the use of the 5S and the other instruments.
The introduction of the robotic assisted procedures is valid for the private and for the public medical care centers in spite of the fact that the motivation is not the same. In the private centers the investment capacity is much higher and the final goal is to offer quality services in a very profitable way. In the public sector the number of patients is much larger; the investment possibilities are lower and uncertain. Even in the existing financing conditions the acquisition and the implementation period of a robotic assisted solution is much larger, extended due to the different involvement. In the public sector the sustainability of the activity being based on a social necessity that must be maintained on running, in the confrontation between the diminishing of the medical staff number and the increase of the patients number. The medical doctors quality is not an issue but a way to easy their activity by the introducing, in stages, of the robotic assisted solutions.
Our up to now expertise in robotic systems was oriented in the medical applications towards laparoscopic surgery, brachytherapy and the after stroke rehabilitation. In the recent meet & match conference and brokerage event, organized by the North-West Reginal Agency in Romania, the discussions with large hospitals CEO, Regional Investments departments, Healthtech community, International development directors, representatives from Galician Health Ecosystem, and other representatives of medical universities and medical care units leads to the conclusion that our system for upper and lower limb robotic assisted neurorehabilitation after stroke, rise the most interest, not only as the single developed solution in Romania but also because is considered really performant and interesting at its IML3 level within the Integration Maturity Level classification (see the figure 5), with demand to be introduced on the regional and national market.

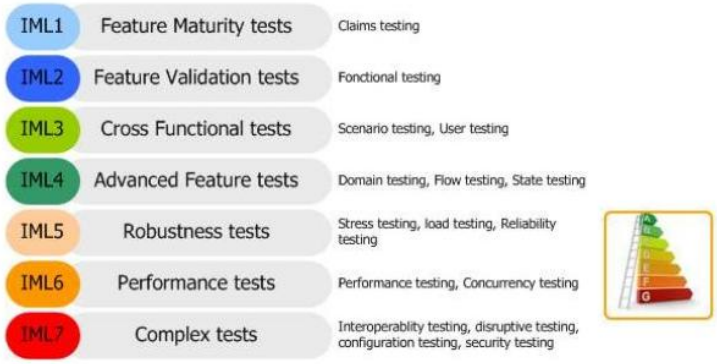

Figure 5 Integration Maturity Level Classification [11]

It is very difficult to introduce any new product within medical system, therefore our efforts and results are highly appreciated. The recent advanced research in developing the IML3, building a feasible IML4 and looking for investors to start the reliability tests for reaching the IML5. All that leads to make a correspondence with the Lean Management concept. So the implementation of our robotic assisted neurorehabilitation system to be preceded by the four steps that lead to the introduction of Lean Management in an organization PTDC: planning, training, developing and coaching (figure 1).
This new vision is beyond an entrepreneurial activity considering that is a solution started within the laboratory in a university research center. The vision implies that up to this stage the engineering development to be made in parallel with the CE certification fulfillments, the medical requirement homologation process, but also dissemination to medical official representatives and the public to create the necessary awareness and to start the introduction of the Lean Management procedures and methods within the medical centers.
The feasibility of the vision and the process consists in starting the robotic assisted neurorehabilitation system lifecycle management with two engineering and management aspects: durability and costs [12]. The stroke is a medical emergency that needs prompt treatment in the acute state and early and long lasting actions for the chronical

phase to minimize the brain damage and potential complications. Now the stroke affects elderly people, since 2015 the average age were over 70, but we see younger and younger people affected by stroke and at larger scale. If in the first case we face people in pension with limited financial resources and needing recovering for an assistive active leaving (AAL) for about 10-12 years period with assistance from their families, in the second case there are people with financial resources (that might disappear due to their condition) needing to be recovered to continue an active – working able - life and also to be able to support their families.

Regardless to the financial status of the medical center, private or public, and the support from different foundations, ministries but mainly from the Romanian national health insurance agency (CNAS), the implementations of a robotic assisted neurorehabilitation system will be seen as a pilot project that can be enlarged (based on results) to a medium scale up to a regional scale. This is a structure encounter for different specializations in countries like Austria, Germany or Switzerland.

The steps and the implementation methodology must be combined in this new approach. The PAT - Process Analytical Technology, can be used form the beginning as the Framework for the robotic assisted neurorehabilitation system implementation and operation, being a specialized mechanism to design, analyze and control, developed by FDA – Food and Drug Administration. The assimilation of the robotic assisted neurorehabilitation system as a multilevel impact matter will help in following all the steps design, analyze the entire requirements fulfillment and control the robotic system operation during its entire lifetime [13].

The PTDC Lean Management implementations steps starts with the Planning, but in this case the actual situation is null and we may start form a location, human and other resources availability and the structure of the robotic assisted neurorehabilitation system. Based on that is designing the Targeted conditions overlapping the robotic assisted neurorehabilitation system requirements with the location the involved personnel and the allocated time frame. The involved personnel, the upper management and the robotic system development team that together forms the implementation team. The implementation team starts the design of the future rehabilitation department the Target definition. Imagining working scenarios, challenges, conformities and emergency situations and submits a proposal. The proposal will be confronted with the allocated resources that may involve some adjustments. The important part of the Target definition is that contains not only the aim of the implementation but also the fluxes. Fluxes of: caregivers, data, documents, materials, medical staff, operators, patients and waste. The patients' fluxes are more differentiated. Starting with the stroke patients, but in a hospital we cannot separate the patients' access based on such diagnostic exclusivity. The comorbidities considerations and the common therapeutically aspects will add in a medical center beside stroke the people with: arthroplasty, cerebral palsy, elbow and shoulder (upper limb) postoperative recovery after stenting, hemiplegic patients, multiple sclerosis, muscular atrophy, muscular hypotonia caused by immobilization, postoperative brain tumor recovery, spinal cord injury, traumatic brain injury, etc.

The only successful implementation solution for managing all this fluxes, the therapies and to operate the upper and lower limb robotic system for rehabilitation assisted, by making an entire training process that must be planned and executed. The terminology and the practical skills are developed in three different training sessions.

Prior the logistics investments can be made a training session in 3 stages: the theoretical lectures and presentations, the hands-on training and the collaborative training in the last stage and as continuous education. After that the investment the implementation and development operation will follow, based on the DMAIC method: Define, Measure, Analyze, Improve and Control. In the end the collaborative training together with the maintenance activity and remote technical assistance will be transformed in the Coaching process, assisting the medical staff and patients in all their activities.

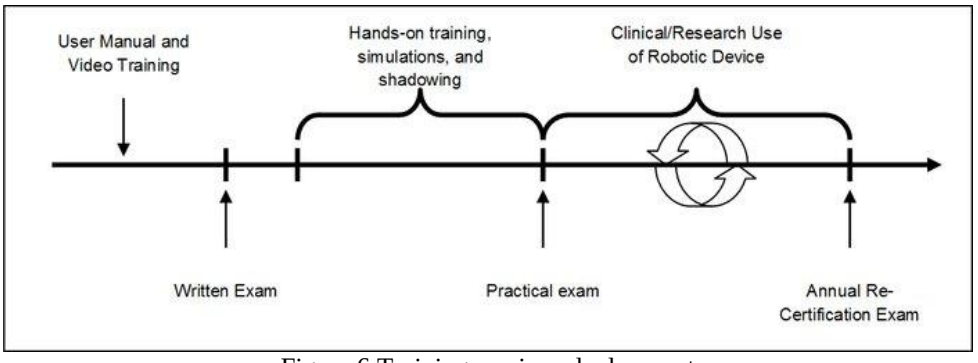

Figure 6 Training sessions deployment

V. CONCLUSION

A special value of the described project is given by the fact that this is a debut of Lean management implementation in Romanian healthcare system. The project proved that even an accurate environment, as a Pathological Anatomy Laboratory, can be improved using Lean management methods and tools.

Lean management seems to be a perfect instrument to start optimizing the process and activities in any sector. Even though it's simpler to implement Lean management in production where it "was actually born", introducing this philosophy in healthcare sector brings the same satisfaction and spectacular results.

Along with a long list of the perceived results, the most remarkable are the increased productivity by 24,4% in the slicing phase of the process, and therefore people in medical field should be aware of what value is and what an importance they have in creating it and so can be extended to other departments, especially to introduce robotics within the after stroke rehabilitation process.

VI. ACKNOWLEDGEMENT

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