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LEAN THINKING IN HEALTHCARE: REVIEW OF IMPLEMENTATION RESULTS

Abstract: *For over decade, automotive industry originated lean concept has been successfully implemented in healthcare systems as a management method and philosophy with main focus on elimination of all types of wastes and losses in all tasks and processes so that time, materials, resources and medical procedures could be realized as effectively as it is possible. As main result lean concept implementation ensured to healthcare organizations to focus on their main core function and dedicate more time and efforts to patients without additional costs for them or healthcare system. However, lean implementation in healthcare could be much more difficult than in standard industrial environment and there are significant number of examples of lean in healthcare projects that failed to gain any measurable results and sustainable benefits from it. This paper presents review of some of the most successful implementations of lean tools and principles in healthcare organizations.*

Keywords: *lean, healthcare, kaizen*

1. Introduction

Healthcare systems and units, worldwide, focusing continuous pressure to reduce all types of costs for its services from one side, but also, on the other side, to increase quality, reduce response, waiting and lead time, improve patient safety, constantly introduce advance and costly methods and equipment in everyday practice. Those demands represents joint framework for healthcare management in developed and developing countries in their search for solutions, methods and techniques which will ensure satisfaction of all requirements and achieving of defined targets.

One of most promising resource for further improvement of healthcare management

for all healthcare service providers, especially hospitals and clinics, is recognized in industrial management strategies accepted and implemented by largest multinational corporations and huge number of other large to small and midsized companies around the globe. Although there is number of different names for those strategies (Lean production/philosophy, Toyota Production System, Lean/Six Sigma, World Class Manufacturing, Kaizen, etc.) in scientific literature, books and papers term "lean" as concept for management of production and business systems is generally accepted and used.

2. Lean Concept and Philosophy

Originally developed in 50's and 60's of 20th century, in Toyota automotive

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company, this concept represent Japanese answer to challenges of western competition, especially from USA, and one of main busters that ensured economical growth of Japan after WWII. Impressed by intensive growth of Japanese industry in relatively short period, scientists from western countries perform detailed studies in late 80's which lead to introduction of lean concept (known in Japan as Toyota Production System) outside of Japan (Liker, 2004).

Today lean concept is widely accepted and implemented set of tools, methods and techniques in numerous companies around the world (Bortolotti *et al.*, 2015). In its fundament lean represents philosophical approach towards management, focused on identification and elimination of all types of wastes and loses and continuous improvement (Womack *et al.*, 2003). Results of successfully introduced lean concept could be evaluated by increased value in production and business processes, redesigned and prepared to offer customers exactly what they want in parallel with increased quality, improved safety, reduction of delays and failures.

From its purely industrial origin lean concept found its way to other areas and sectors. Healthcare, as important and complex sector in every society, also recognized importance and benefits of lean implementation and today represent one of most promising and prospective areas for further expansion in number of involved hospitals and healthcare sectors from one side and variety of used tools, methods and techniques from other (Mazzocato *et al.*, 2010).

For each healthcare subject waste could be identified as anything that does not add value to healthcare service from the patient point of view, so it is extremely important to identify and recognize all activities that are value-added, than non-value added but necessary activities, and finally purely non-value-added activities (Aherne and

Whelton, 2010). For example value-added activities in healthcare system are diagnosis of illness, treatments of injuries, performing of laboratory analysis. Related to previous, preparation activities for treatments and diagnosis procedures could be assumed as non-value added but necessary as they are not directly oriented to patient but are mandatory in scope of previously mentioned, value-added activities.

Finally significant number of non-value added activities examples could be identified in each healthcare subject, like all types of waiting, performing of unnecessary jobs, delays etc. Inspired by Toyota "seven deadly wastes" (plus additional one defined by Liker, 2004) eight main types of wastes in healthcare could be identified, often summarized with the acronym D.O.W.N.T.I.M.E (Grabau, 2012):

- **Defect** (performing of wrong procedure),
- **Overproduction** (unnecessary treatments, more than needed or before its needed),
- **Waiting** (patient or staff waiting's for various reasons),
- **No use of staff** (underutilizing medical staff knowledge, skills and talents),
- **Transportation** (unnecessary movement of patient, equipment, staff),
- **Inventory** (excess medication, unnecessary medical material and equipment),
- **Motion** (employee walks to distant areas to get supply), and
- **Extra processing** (generate duplicate documents, repetition of procedures, examinations, or performing medical procedures by staff with higher qualification than it is needed, etc).

3. Most Frequently Used Lean Tools in Healthcare

5S methodology

5S is the name of methodology for workplace organization which is generally accepted as one of cornerstones for implementation of Lean concept. It is usually performed at the beginning of a Lean introduction combined with establishing of internal rules and standards which will ensure maintaining of achieved results in unlimited period after implementation. 5S represent acronym for five activities named by five Japanese words (and their English equivalents) starting on letter "S" that should be undertaken in sequence. Those activities describes how to organize a workplace and work environment for efficiency and effectiveness improvement by performing of items sorting, ordering and workplace detail cleaning followed by standardizing and sustaining activities in order to maintain new order. Latest trends and recommendations go in direction of introduction of sixth "S" for Safety. As safety (patients and staff) should be assumed as one of top priorities in healthcare, its further strengthening through 6S (5S + 1) implementation in healthcare organizations can be additional benefit measured in meaningful and sustainable improvements in safety practices (Ikumaa and Nahmens, 2014). Successfully realized 5S projects have been documented in a number of healthcare subjects in a range of departments from patient facilities to finance, laboratories, administration and offices (Esain *et al.*, 2008). Presented results show that 5S can be applied to healthcare services with beneficial effects such as cleaner, organized, efficient workplaces for enhanced safety and increased productivity, reduction of inventory and supply costs and recapturing of valuable spaces and minimizing

overhead costs where well established sustainability is a key to success (Young, 2014; Amasaka, 2015).

Kaizen - Continuous Improvement

Continuous improvement or Kaizen (Japanese word globally accepted as term for continuous improvement) represent philosophy approach focused on problem solving through gradual, orderly and continuous "change on better" in some or all the elements of the process. When it is applied to the workplace, Kaizen refers to activities which involve all employees and that continuously improve all functions and processes through elimination of waste. As other Lean tools and methods, Kaizen is first introduced in industry and is now being implemented in various environments and sectors outside of production.

Each Kaizen event should be planned and realized upon, so called Deming's cycle or PDCA cycle (Plan - Do - Check - Act). This assume problem identification, analysis and definition of improvement solution in first step (Plan), testing in small, controlled, model zone in second step (Do), evaluation of obtained results (Check) and adoption or adjusting of improvement activities in final step (Act). Kaizen events should be planned, executed and evaluated in regular meetings using well-structured teamwork activities. In healthcare organizations Kaizen has been found helpful in improving the work organization, utilities using, patient care process together with waste reduction in number of specialties and departments (Jacobson *et al.*, 2009; Iannettoni *et al.*, 2011; Smith *et al.*, 2012)

There are several factors which ensure measurable results in Kaizen implementation in healthcare like easiness for training and introduction, motivation of staff, focus on low-cost and low risk improvements, involvement of all employees in process of improvement

proposals and implementation, transfer of improvement implementation analysis and testing to originators of idea, respect to all ideas no matter of size and impact (Graban, 2012).

In initial phases of Lean implementation, slow, continuous changing/improvement processes could sometimes be not effective enough, when modification of kaizen approach is often used. So called Kaizen blitz, or Rapid Improvement Event (RIE), is a focused, fast performing and significant changes initiating activity used for general modification and redesign of observed processes and identified problems. The basic concept is to identify and quickly remove waste (Liker and Meier, 2006). In practice a Rapid Improvement Event is generally completed in few days (1 to 5) and involves key process participants focusing on solving a narrowly scoped process improvement opportunity.

Value-stream Mapping (VSM)

In its origin value-stream mapping (VSM) is graphical, analytical tool that allow simple representation of flow for selected part of process, from its start (material purchase from supplier) to finish (final product) (*Learning to see*). VSM show times and resources used in each step of process, waiting's between steps, inventories size, information and materials flow, workforce performance in terms of cycle time per product (activity) and change-over time when switching between products (activities). It is method that facilitates the Defined VSM for one process, showing present "as is" state, represent base for analysis of week steps, bottle-necks, excessive inventories, missing resources, misbalance in process steps and definition of corrective actions for process redesign and reorganization for achieving of necessary improvements and better process effectiveness.

VSM is one of most frequently used Lean tools in healthcare organizations for analysis of current state or identifying areas of potential problems and development of a future state or creates solutions design for identified problems. In its healthcare use, VSM is manly the diagrammatical representation of the patient's journey through the system, and its ensure identifications of each individual step in treatment and other medical procedures, their value, duration, interrelationship, process failures, staff-staff and staff-patient relationships, etc. (Sampalli *et al.*, 2015). VSM has been proofed as successful tool for initiating of healthcare system changes in order to provide insight into system improvement opportunities and bring optimal level of all basic three requirements for each healthcare process and activity – price, quality and on-time delivery. VSM have also been widely used in reducing wait times in emergency services (Eller, 2009).

Visual Management

Coming from the fact that humans are intensively visual beings and that majority of information's that we received and accept from environment comes through sense of seeing, Lean concept put significant importance on implementation of visual management tools and techniques as a way for establishment of fully visual workplace. The aim of Visual Management (VM) is to create a work environment that is self-explaining, self-ordering, self-regulating and self-improving, where what is suppose to happen does, on time, every time because of visual solutions (Galsworth, 2013). VM is a concept of various visual tools (signs, colors, markings, info boards, lights, etc) on hospital premises to organize area, monitor work, appliances and equipment in use. Visual management reinforces patients and employees safety because of self-restraint feature.

4. Lean in Healthcare: Implementation Results Review

In frequently cited paper (Fillingham, 2007) results of 18 months project from Royal Bolton NHS Hospital, UK dedicated to exploring whether or not lean methodologies can indeed be applied and implemented to healthcare, is shown. Author reported impressive results with 42% reduction in paper work, better multidisciplinary team working, and a reduction in length of patient stay by 33%. Coming from very high defined goals, stated in paper title "Can lean save lives?" author concludes researches with positive answer supported by reported significant

reduction in mortality of 36%. He recognized lean inspiration and encouragement potential and although it cannot be simply translated into a healthcare environment it was shown that numerous lean methods and principles could be adapted and developed for purposes of healthcare staff using and focused towards the goal of improved patient care.

This hospital is often stated as one with most successfully developed and implemented lean program in complete healthcare system in UK (Radnor *et al.*, 2012). Table 1 show some additional results from this hospital compared with two USA and one Scotland based facilities.

Table 1. Examples of successful lean implementation in hospitals

Organization	Impact
Scotland Cancer Treatment	<ul style="list-style-type: none"> • Reduction in patient waiting times for first appointment from an average 23 to 12 days • Patient flow time improvement of 48%
Royal Bolton Hospital	<ul style="list-style-type: none"> • Direct savings of £3.1 millions • Reduction of time taken to process important categories of blood from 2 days to 2 hours • Average turnaround time in pathology reduction from over 24 hour to 2 - 3 hours
Nebraska Medical Centre	<ul style="list-style-type: none"> • Reduced staff walking distance • Reduced lab space and specimen processing turnaround time by 20% • Reduced manpower and their transfer to other critical points • Decreased numbers of days of average patients stay from 6.29 to 5.72 days.
Pittsburgh General Hospital	<ul style="list-style-type: none"> • Intensive care unit cost reduction of almost \$0.5 million per year • 90% reduction in number of recorded infections after 90 days of implementation of changed procedure for intravenous line insertion.

The Virginia Mason Medical Center (VMMC), Seattle, USA which includes Virginia Mason Hospital and a network of primary and specialty care clinics initiate in 2002., program for general lean implementation through introduction of self

developed system called Virginia Mason Production System (VMPS) (Furman and Caplan, 2007). This integral system was based on total people involvement (TPI) principle, understanding that medical and administrative staff are fully aware on

existing problems and have the best solutions for them. VMMC uses several lean improvement tools and techniques, such as Rapid Improvement Events (RIE's) focused on rapid changes, Continuous improvement - Kaizen events focused on incremental changes, 3P (Production, Preparation, Process) as a tool for complete process redesign. During first eight years more than 850 continuous improvement activities were performed involving staff, patients and guests

Presented results (Furman and Caplan, 2007) show that VMPS implementation ensured to VMMC respectable position in the top 1% of all hospitals in the U.S. in terms of both quality of patient care and system efficiency, with numerous examples of achieved improvements:

- Decreased the number of hours when the Emergency Department was closed and unable to receive new patients by more than 90 percent.
- Reduced lab test results reporting time to the patient by more than 85%.
- Increasing of patient safety through introduction of the Patient Safety Alert system followed by reduced premiums for professional liability insurance by 56%.
- Nurse walking distance was reduced in the hospital by 750 miles per day, freeing up more than 250 hours of staff time spent walking for direct patient care.
- Increased productivity by 93% in a few selected model areas by introduction of kitting principle (creating kits containing frequently needed supplies).
- Using space more efficiently ensures \$11 million savings in capital investment and freed an estimated 25,000 square feet of space using better space designs.

- Reduced inventory costs by \$2 million through supply chain expense reduction and standardization efforts.

Analyzing lean as system of thinking and staff learning platform, rather than just set of tools, in paper (Ballé and Régnier, 2007) authors reported use of lean in a French Nord 92 hospital in project for reduction of a number of complex nursing issues, such as medication distribution errors, catheter infections, *hospital-acquired* infections, bedsores, through implementation of 5S, standardized work, A3, etc. Over the first two years, the rates of such incidents per patient were reduced by 45 percent.

Lean inspired methods were used for decrease hospital-wide central line associated bacteraemia (CLAB) on the intensive care unit (ICU) at Allegheny General Hospital, Pittsburgh, USA (Shannon *et al.*, 2006). As CLABs are recognized, not as an inevitable product of complex ICU care, but the result of highly variable and therefore unreliable care delivery, two ICU's, in this hospital, redefined the processes of care through redesign of system in order to deliver reliable outputs with minimal variations that showed to be simulative factor for infection spreading.

Based on lean principles and root cause analyses, Perfecting Patient Care were established and applied to central line placement and maintenance empowered the workers to implement countermeasures designed to eliminate the defects in the processes.

Processes redesign were prepared and implemented within just 90 days and within a first year CLABs decreased from 49 to 6 (10.5 to 1.2 infections per 1,000 line-days), and mortalities from 19 to 1 (51% to 16%), despite an increase in the use of central lines and number of line-days. These results were shown to be sustainable during prolonged period of time.

Improving of blood draw and specimen collection process for the Emergency

Department (ED) of the Vidant Health Centers, Greenville, North Carolina, USA was performed with lean/six sigma methodologies implementation (Sanders and Karr, 2015). Those are standard processes used in hospitals to collect blood chemistry and hematology information. The approach used in this project was based rapid improvement event (RIE) or Kaizen blitz event, as a lean tool for rapid process improvement. Project were prepared and realised by Emergency department, Hematology and Chemistry Lab personnel and focused in its core to the most frequently ordered blood tests and cultures.

Significant reduction in specific laboratory material and consumables usage were recorded (30 to 50%) followed by decrease in observed defects, delays and deviations measured in median laboratory turnaround time (TAT) reduction from 2 to 18%.

Similar results were presented in the study of White *et al.* (2006), dedicated to applying lean methodologies at Emergency department of Massachusetts General Hospital, Boston, USA. The intervention was a focused lean based reorganization of laboratory process flow, which significantly increased process efficiency. After reorganization of laboratory process flow, significantly increased process efficiency was recorded, measured in median laboratory turnaround time (TAT) decreased across most tests. The greatest decreases were found in troponin TAT which was reduced by 33 minutes (37.5%), urine sedimentation TAT reduced by 88 minutes (75%), troponin I TAT reduced by 12 minutes (30%), urinalysis TAT by 10 minutes (35%), and urine HCG TAT by 10 minutes (36%)

Chen *et al.* (2014) analyzed the results of lean management work implementation to improve the admission and blood result waiting time at Emergency Department (ED), Alice Ho Miu Ling Nethersole Hospital, Hong Kong, China. Identification of all steps in the patient pathway from

process beginning to the end and quantification of value-added and non-value-added time in each step were performed by using of Value-stream mapping (VSM) tool. All relevant times were measured and analyzed (triage time, waiting time, intervention time, admission time and processing time). Project showed that application of lean management can improve the patient flow in ED and enhance high quality emergency care and patient satisfaction. After implementation of lean based management methods included structured process redesign, priority admission triage (PAT) program introduction and enhanced communication with medical department, triage waiting time and end waiting time for consultation were significantly decreased together with admission waiting time decreasing by 55% after implementation of PAT program.

Improving of patients workflows were also targeted in study performed at Department of Radiology, Medical College of Wisconsin, USA (Shah *et al.*, 2013). Application of lean principles to screening mammography workflow has improved the efficiency and decreased patients waiting time. The implementation of lean philosophy started with patient-centred approach and analyzing of patients-defined valuable activities and the problems to be solved. Used lean tools included VSM, identification of waste, 5S tool, forming of process map and visual management based communication. Among other things, portable electronic were used to verify patient identifiers and electronic work list were formed and images were digitized before patient's appointment. After the implementation of lean philosophy patient waiting time was reduced for amazing 70% (from 11.1 to 3.3 minutes). Also, total visit length was reduced for 23.4% (from 33.7 minutes to 25.8 minutes) and read times for screening mammography for 40% (from 4.8 minutes to 2.9 minutes per case).

Lean approach has been used for the several years at the Department of Radiology, Beth Israel Deaconess Medical Center to improve

performance and efficiency (Kruskal *et al.*, 2012). The goal of this implementation was primarily to improve flow of patients with uninterrupted equipment function, but lean transformation of work philosophy and workplace culture was done. Several lean tools were used like Value stream mapping for visualizing the current state of a process and identifying activities that add no value, root cause analysis, visual management techniques and boards, balanced scorecard etc.

Improvements of patient workflow and significant time reductions in performing of standard medical procedures are directly connected with significant financial savings. The pediatric multidisciplinary reconstructive pelvic medicine clinic of Children's hospital, Seattle, USA, (consisted of pediatric specialists in urology, general surgery, gynecology, and gastroenterology) has utilized lean methods to enhance operational efficiency and improve value for patients (Merguerian *et al.*, 2015).

Initial MD (medical doctor) preparation time reduction from 8 min/patient to 6 min/patient, while MA (medical assistant) preparation time was increased from 9.5 min/patient to 20 min/patient. This time redistribution resulted in cost reduction of 41%, (\$366 per patient).

Continued improvements further reduced the MA preparation time to 14 min and the MD preparation time to 5 min with a further cost reduction to \$194/patient (69%). Number of appointments per clinic was increased without affecting quality as the valuable time spent with each patient was not reduced.

Value stream mapping (VSM) prove itself to be very useful and thus frequently implemented tool in lean healthcare for process analysis in present state, various wastes and loses identification and definition of improved process structure. VSM were used as core tool in program for wait time reduction in hospital in New Scotia, Halifax, Canada (Sampalli *et al.*, 2015).

Performed project comes from fact that patients who have delayed access to relevant care, particularly those with complex conditions (chronic illness and multimorbidities) in further period become frequent and demanding users of various medical standard and emergency care (from primary care, community care, and acute care to professionals and specialists). This imply main goal for this action to provide timely and relevant access to care for population with high needs with additional target to remove waiting times for complex and chronic illness care.

Integrated Chronic Care Service (ICCS) in this hospital have near 10,000 patient visits each year. As a result of performed activities waiting times for new patients have significantly reduced from approximately 13 months in 2012 to 2 months in 2014 with trend which imply that there will be no wait times for new patients in 2015 to receive ICCS intervention. Remaining wait times was reduced by about 40% (from 48 to 29 weeks). Discharge rates for ICCS have improved significantly >10% since introduction of process changes, also referral rates increased by 20% since 2013 (Sampalli *et al.*, 2015).

One of the first studies about implementation of lean healthcare methods in hospitals from countries outside of West Europe or USA was the study of Costa *et al.* (2015), with presentation of results of lean implementation in two Brazilian hospitals. (Sterile services department and pharmacy - hospital A and chemotherapy, surgery and radiotherapy - hospital B). The lean system was implemented trough two phases.

Instead of standard PDCA cycle, authors used DMAIC cycle (Define - Measure - Analyze - Improve - Control), originally derived from Six Sigma approach. In order to define the problems VSM was created and for its solving a Kaizen Event was conducted, including different tools as 5S, Visual management and Kanban board for the proper arrangement of materials and

tools, packaging and reducing the material waste.

The results of lean implementation in sterile service department were 78% cost reduction, 94% reduction in delayed surgery due to lack of material, 1–1.5% to 0.21% reduction in infection rate in clean surgeries, reduction of the setup time between autoclave cycles by 30 min and reduction in autoclave cycle time by 30 min. Lean system in pharmacy department led to orderly supply of hospital units, reducing the stocks an significant reduction of costs.

Main goals of introducing lean methodology in chemotherapy department were reducing patient lead time and to improve financial aspects. The obtained positive results were 33% increase in monthly financial income, 23% increase in the number of chemotherapy applications, 42% reduction in average

patient lead time and 50% reduction in the number of patients waiting to begin chemotherapy.

5. Conclusions

This paper presented review of selected successfully finished projects oriented to lean implementation in healthcare. Obtained results show that various medical processes in different departments could be significantly improved with measurable and valuable benefits for patients and hospitals.

Observed healthcare systems, obviously, had high level of organization and management in initial phase yet they realized remarkable results thorough lean concept, which should serve as inspiration to all others, no mater of their present condition and performances.

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