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Reducing Errors by RFID Technology to Achieve Lean Healthcare

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Abstract

Reducing wastes in the healthcare processes is crucial for developing a high performance health system. Adopted from the Toyota Production System (TPS), the Lean concept has emerged in recent years as a way of introducing innovative ideas to improve industrial processes. In the context of healthcare, Lean is considered as a continuous improvement model, which provides healthcare organization to identify and remove the wasteful activities. Implementation of Lean concept can benefit from the use of new technologies that facilitate management of patients, human resources, and inventories. RFID is one of these technologies, which can help removing non-value added activities in the healthcare processes by its traceability and real-time provision of information. The purpose of this paper was to systematically explore how healthcare organizations can take the advantage of RFID to optimize their process and create value added towards ultimately becoming Lean. We categorized the major advantages of RFID in the context of healthcare and the Lean scopes that can benefit from RFID, and discussed the relationship between the two concepts.

Keywords: Lean, RFID, Healthcare, Waste reduction, Hospital management, Healthcare process, Healthcare organization, Healthcare system

Background and Objectives

Healthcare Organizations (HCOs) are complex and multi-dimensional organizations with great responsibilities towards public health [1]. Reducing waste in healthcare system and improving its efficiency is a global challenge, also highlighting the need to identify any source of potential improvement and leverage on any tool, technique, methods and technologies to improve healthcare delivery and services around the world [2-3]. Unlike some organizations that operate in very low risk environments, healthcare environment is characterized by its close proximity to save human lives where risks are extremely high. This translates to the constant need to maintain a high level of operational effectiveness and quality in healthcare delivery even when efficiency, cost and schedules are overrun [4]. In this regard, using approaches to measure efficiency can be very useful [5]. A recent review on the use of such methodologies in the public sector revealed that 51% of publications focused on Lean, a further 13% on Business Process Reengineering (BRP), with 35% stating their use in health services [6]. Although conceptually simple, it is not easy to define 'Lean'. The core philosophy is to continually improve a process by removing non-value added steps or 'waste' (Japanese: 'muda'). The initial wastes were defined by Taiichi Ohno for a manufacturing environment and have been adapted for the healthcare context [7], e.g. by the English National Health Service (NHS) Institute for Improvement and Innovation [8]. The system (known today as Lean production) originated with Toyota five

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decades ago as the Toyota Production System (TPS) [9, 10]. In a Lean production system, products and services are produced only as they are needed by the downstream customers, where some concepts such as Kanban, 5S, Jidoka, Visual Control and Poka Yoke are applied to achieve this goal. Lean for healthcare is a continuous improvement structure, adapted from the Toyota Production System (TPS), which provides a way for healthcare organizations to manage the required change. Ongoing research at Montana State University and Community Medical Center in Missoula, Montana, has adapted several key tools and principles from Toyota to healthcare, and demonstrated their effectiveness in improving hospital operations [11, 12]. Also a growing body of research examines the implementation of Lean methodologies within healthcare, often showing the benefits to patient care and resource utilization [13-18]. However, research also suggests that the implementation of Lean is not without its problems, with the process depending on such factors as organizational readiness, a culture of continuous improvement, effective leadership, the availability of resources, and communication strategy [16]. According to the reports, applying Lean principles from manufacturing to healthcare settings was demonstrated by hospitals such as Denver Health Medical Center [19], In 2006, the hospital saved about $2.8 million without reducing staffing or patient care [20], ThedaCare, a hospital system in Wisconsin, also initiated its Lean improvement by studying manufacturing systems and saved $10 million in 2005 due to its Lean programs [21]. Lean approaches have produced other measurable improvements such as shortened time to admit patients at Prairie Lakes Healthcare [22].

New technologies for the management of patients, personnel, and inventory promise to streamline the efficiency and effectiveness of hospital functions [23]. One of them (seen as carrying significant potential to improve the healthcare) is Radio Frequency Identification (RFID). Prior to the Wal-Mart (June 2003) and the U.S. Department of Defense (July 30, 2004) mandates, RFID had been flying below the business innovation radar [24]. Healthcare is considered to be the next home for RFID after manufacturing and retail [25]. RFID is an important element to improve healthcare, which enables a fully automated solution for information delivery, thus reducing the potential for human error and increasing utilization. IDTech (2008) predicts the market for RFID tags and associated systems and services in healthcare to rise from $120.9 million in 2008 to $2.03 billion in 2018 [26]. Nevertheless, despite the obvious benefits of deploying RFID technology, there are some apparent down sides, too. High costs, difficulty integrating with legacy systems and interoperability with life-saving medical equipment, incompatible communication standards across major entities in a healthcare network, and entrenched work practices are all potential obstacles to effective adoption and use of RFID in healthcare settings [27].

In this paper, we will explain systematically how a healthcare system can use RFID benefits to optimize it's processes and create value added to become a Lean system. For this purpose, first we will categorize RFID's major advantages and scopes of Lean healthcare and examine the relationship between them. Then we will explain how RFID can help in going to the Lean healthcare.

The reminder of this paper is organized as follows: Section II deals with a brief review of issues related to Lean healthcare and RFID in healthcare. Section III considers the introduction of RFID technology and its cost implementation and its benefits. Finally, we offer implications and our conclusion to the study, followed by limitations of the study and future research.

Literature survey

There has been for several years a discussion that ubiquitous technologies and smart, interactive devices are proliferating, and there has been significant speculation about what this means in many domains, including medicine [28]. A qualitative study conducted by Fisher and Monahan [29] of hospital staff members employed by three U.S. hospitals, who use RFID technology to track their personnel and assets, uncovered an unintended consequence of the hospitals' use of RFID. The interviewed hospital staff members, particularly the nurses, expressed negative views of the hospitals' use of RFID, including concerns that they were being overly scrutinized and, as a result, felt like "big brother" was watching them. Thiesse et al. [30] investigated one side of this gap by examining individual perception of risk and how it impacted RFID adoption. Thiesse had called for an "open dialogue" with the users to create "technology trust" along with security measures. Janz et al. [31] studied an RFID application at a Level-1 trauma unit in the emergency department of a hospital, and found that data collected from the tagged patients helped improve medical processes, decision making, and resource management. Angela et al. [32] focused on RFIO technology in hospital environments and discussed about the potential benefits, the areas of applications, the implementation challenges, and the corresponding strategies of RFID in hospital environments. Remko et al. [33] presented a

framework that can be used to assess the performance of RFID systems within the healthcare settings. They concluded the potential risks that RFID technologies may bring to the healthcare settings should be thoroughly evaluated before they are introduced into a vital environment, and the RFID performance assessment framework that they presented can act as a reference model to start an RFID development.

The precise date of the first application of Lean in healthcare is uncertain, but from a historical perspective, Lean first appeared in the UK health service in 2001 and then in the USA in 2002 [7]. However, the literature suggests considerable variability in the implementation of Lean with differences in approach and scope. Specifically, the majority of healthcare providers tend towards small enclosed projects that create 'pockets of best practice' rather than adopting an organization or system-wide approach [6, 34]. Luciano [34] points to this theoretical category that there are three reports that distinctively discuss the potential of Lean healthcare, and simultaneously provide a comprehensive insight on how Lean, as a manufacturing approach, can be translated into healthcare [35-37]. The first report addresses key similarities between manufacturing and healthcare, and describes how some of the tools can be translated from manufacturing into healthcare, and presents two organizational case studies. The second one comprises two case studies (one manufacturing-like and the other patient flow related). In the third report, Jones and Mitchell reflect on the benefits of Lean, and analyze the main challenges to implement Lean in the British National Health Service (NHS).

Francisco et al. [38] analyzed the benefits that can be derived from the joint use of Lean principles and RFID technology in healthcare. Document tracking and spare parts for surgery were the most interesting purposes of their paper. Landry et al. [39] examined RFID and Lean healthcare and applied the Lean healthcare concept to their analysis of how the two-bin system can increase the efficiency of hospitals. They also addressed how recently introduced RFID technology could enhance the performance of the two-bin system, allowing the status of stock on wards to be known as soon as labels are removed. This permits inventory to be managed proactively, helps optimize replenishment rounds, and alerts the materiel management department of the potential stock-outs of the ward.

Discussion

RFID Technology

Radio frequency identification (RFID) is an automatic identification and data capture technology, which consists of five main components:

1. A RFID tag, which could be either an active or passive tag.
2. A RFID interrogator (also called a Reader).
3. An air interface for wireless connectivity.
4. Processing architecture (middleware) such as a computer system.
5. Applications, which could use the RFID information for further processing.

A tag formed by a chip connected with an antenna; a reader that emits radio signals and receives in return answers from tags, and finally a middleware that bridges RFID hardware and enterprise applications [40].

These days, RFID is usually related to the retailing and manufacturing industries. Therefore, it must also be acknowledged that these industries are driving development presently taking into account that major retailers such as: Wal-Mart, Tesco, Metro etc. RFID is also widely used in facilitating electronic transaction (e.g. Toll collection in the U.S., Octopus card in Hong Kong, or Oyster card in London), logistic and supply chain management (e.g. the Internet of things), manufacturing and assembly (e.g. the assembly of cars), express service (e.g. American Express), scientific research (e.g. tracing snakes and migratory birds), medicine (e.g. identifying a specific patient), and security (e.g. access control) [41].

RFID Cost

The cost of acquiring, installing and maintaining an RFID system is a key and influential factor in the use of this technology. There appears to be great variety and little quantitative information in the overall costs of acquiring, installing, supporting and retaining an RFID system. RFID system cost is made up of tags, readers, and processing and supporting information technology hardware and software. Higher adoption rates will cause system costs to drop and encourage more RFID users [42]. The costs due to RFID implementation are classified in Figure 1.

RFID Benefits

Over the years, RFID tags have been successfully incorporated at various levels in a healthcare setting. Healthcare organizations use RFID to ensure the health and safety of patients and medical personnel, and to uncover inefficiencies in operations. RFID systems allow for the electronic tagging of assets, inven-

tory, personnel, and patients. Since RFID tags do not need a battery and recharging (and so have no battery power loss problems), and are tiny in volume, they can be embedded into different objects. We introduce RFID benefits to be utilized in healthcare processes. RFID technology with three major advantages can eliminate the errors and bring other benefits simultaneously, which can lead to create value added in healthcare. We classified these advantages in Figure 2 as shown.

The basic benefit that RFID brings is automated data capture related to product information, status information, location and environment status. These benefits, especially access to real-time information, are critical for every healthcare system [44]. Also RFID allows seeing the collection of data in real-time while one or more than one object or human is currently relocated. Hence, we have access to visibility in real-time. Maybe, the ability to track materials is the most important advantage of RFID. Because when the drugs, patients and medicine staffs are attached with the RFID tags, we can track them in of the entire healthcare environment. We will explain in the next section how these advantages can help us to remove non-value added steps, optimize their process, and create value added towards achieving Lean.

Approaching Lean healthcare by the use of RFID

To maximize value, leaders in healthcare must identify every step in the process (or "value stream," in the language of Lean), eliminating non-value-added steps, and make value flow by modifying them. As led by Healthcare Performance Partners (HPP), Lean Healthcare is not just another project: "it is a way to transform your entire organization into a safe and high-quality, high-performing healthcare delivery system". Accordingly to [45], Toyota's notion of "ideal" fits healthcare so well that we adapted it as follows:

- Exactly what the patient needs, defect free.
- One by one, customized to each individual patient.
- On demand, exactly as requested.
- Immediate response to problems or changes.
- No waste
- Safe for patients, staff and clinicians: physically, emotionally & professionally.

The concept of Lean manufacturing is equally applicable in healthcare as it is in manufacturing industry and can be supported and triggered by the simultaneous incorporation of new information technologies such as RFID.

Processes either add value to or waste the production of a goods or service. To eliminate waste, it is important to understand exactly what waste is and where it exists. Among recognized seven wastes (Overproduction, Waiting, Transporting, Inappropriate Processing, Inventory, Motion, and Defects), we examined the scopes of inventory, motion, transportation and processing as four basic areas to create value added by identify non-value added steps and remove them through RFID technology. We classified the different parts of mentioned scopes. Their relationship with RFID advantages is shown in Figure 3.

Inventory

Inventory management in healthcare covers drugs, blood products, medical instruments, beds, lab supplies, and equipment. One way to effectively maintain control over the facility inventory is to make sure about the inventory level. A 3% reduction in supply inventories can equate to a 1% reduction in total hospital expenses [46]; however, according to the main duty of healthcare, it is necessary that the inventory be available to use for patients. Also patients with unmet care needs (inventory) have expensive outcomes and a lower quality of life. Additionally, creating a system that responds in real time to patient demands would also help us understand how our own internal practices are driving huge amounts of waste. To solve this problem, RFID technology with its ability to track down each item can help to know precise information about inventory position. Hence, when required inventories exist, RFID can give a good visibility to inventory manager and avoid of un-necessary order act, which has non-value added, besides saving cost and time.

Moreover, surplus inventory can result in wasted space and time searching for products, and can increase the number of expired products due to a lack of control [39]. Because of the nature of medical products, especially blood products, which are perishable; inventory shrinkage can be probable. Shrinkage (named also stock loss) errors include all types of errors that cause loss of items ready to use. Also since different types and quantities of inventory exist in healthcare, some of inventories are not usable, because of the misplacement error that causes inventory shrinkage. Misplacement can be explained as inventories, which are not in the correct place and are not available. When the products are attached with the RFID tags, we can track them and remove the possible inventory errors. Since, searching the misplaced items and putting them on correct place has not value added for healthcare, again RFID can help to eliminate non-value added steps. Also RFID can bring us a real-time visibility to monitoring the inven-

tories such as temperature, moisture monitoring and logging for storage of blood, organs, drugs, vaccines and tissue samples. Real-time visibility allows for dynamic level adjustment and reduces supply retrieval time and waste.

Transportation

Transporting patients from point A to point B (vehicle to bed, room to procedure, even building to building, moving patients for testing or patients for treatment, and moving samples by patients) is an indispensible function in today's healthcare. This relocation can cause some errors such as going to wrong place, safety reduction, going to restricted-area access, reduction in security, and so on. It is necessary to spend much more time to modify them, which have no value added. RFID can give a useful visibility to prevent restricted-area access or to keep a patient from leaving a particular floor, so preventing the later corrective actions, which are non-value added. However tagging people is more challenging because of the organizational issues.

Proccessing

Admission and information processing of patients also is complicated by the increase in outpatient volumes and the associated need to schedule services on short notice. The errors caused by this processing are duplication of information and asking for patients' details several times [5]. Among the most common hospital billing errors are duplicate billing and incorrect room charges, which are non-value added clearly. Since RFID can capture data automatically, it can remove errors. RFID can further increase the speed of processing. On the other hand, personal and medical information of patients are confidential and vital, and RFID-enabled patient ID system can help nurses to improve the quality of patient care, increase safety and reduce length of stay; all of which bring value added to the system.

Motion

One of the challenges of implementing Lean in healthcare is that it requires people to identify waste in the work place. Recognizing that much of their daily tasks is wasteful and does not add value can be difficult for healthcare professionals. A nurse who is hunting for supplies is doing it to meet the needs of patients. Nurses may not see this as wasted time, and may not stop to wonder why those supplies are not available any time they need them [35].

In regard to removal of wastes, RFID with its potentials in real-time visibility and automation capture of date can help nurses to monitor healthcare parts to avoid unnecessary movement and unnecessary relocation of equipment, which are non-value steps. This benefit of RFID can create value added through preparing optimization of resource allocation. This is of particular importance in geriatric healthcare where patients require having special needs. Also RFID-enabled smart shelves simultaneously help item-level inventory management to reduce inventory level and help nurses to know about the exact position of inventories and thus avoid waste motion for finding required drugs and other inventories.

Conclusions

In this paper, we examined how RFID can help the healthcare to become Lean by its advantages. Successful patient care requires that the right supplies are delivered and be available at the right time. It is important for all staff, regardless of scheduling and shifts, to access, supervise and perform medical inventory orders. This can assure proper inventory levels and access; this improvement is a step forward to be Lean. We demonstrated that RFID can create value-added by helping to track inventories and remove shrinkage or surplus. Ability to track the patients and give useful visibility to monitor them, speed up the information processing, improve patient's safety and security, and finally, help to remove waste movement of medicine staff and equipment have well been explained.

The other scopes of Lean in healthcare such as waiting and defects can be analyzed in future research. Also, as mentioned in [47], medication error incidents are among the most important patient safety challenges in the clinical units, and the role of RFID to reduce them can be very interesting. Our limitation in this paper, which was trade-off between the costs and benefits of RFID deployment to achieve Lean healthcare, can be addressed in further investigations.

Competing Interests

The author declares no competing interests.

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