Toyota Production System Design Rules to Improve Delivery of Patient Care: A Case Example

Manimay Ghosh

Abstract

The healthcare industry in the United States has been fraught with medical errors, rising costs, and wastes for many years. Despite widespread adoption of Total Quality Management and Six Sigma programs, healthcare's woes continue unabated. The Toyota Production System (TPS), progenitor of lean manufacturing, is widely regarded as the most effective production system ever devised. It has been successfully adopted by manufacturing firms worldwide resulting in significant gains in efficiency and quality in companies of all sizes. The goal of this work was to determine whether principles from the Toyota Production System could be applied to a healthcare environment to improve its delivery systems.

Key words: *Toyota Production System, Lean Manufacturing, Process Improvement*

The United States healthcare system is known to provide the best possible medical care in the world yet it is riddled with many problems that have concerned most Americans. There are legitimate reasons for such concerns. The current picture of healthcare looks grim: mounting operational costs and diminishing reimbursements from payers, un-even clinical and service quality, overworked staff, high attrition rates, shortage of skilled human resources in various service lines, and very complex and uncoordinated processes with little standardization. Wastes, errors, and duplication of efforts abound in the entire healthcare system (Uhlig, 2001; Berry, Mirabito, and Berwick, 2004; Waldman, Kelly, Arora, and Smith, 2004; Porter and Teisberg, 2004).

Today, the growing body of literature suggests that the healthcare industry is in a serious crisis and does not have sound systems in place. Perhaps the most notable of all these studies and most frequently cited in the literature is Kohn, Corrigan, and Donaldson's (1999) study that reports that nearly 100,000 people die of preventable medical related errors annually in the U.S.

Hospital errors (ordering, administration, transcription, diagnosis) have received considerable attention in recent times because of high defect rates (Merry and Brown, 2002). Despite such high defect rates, caregivers such as the physicians, over the years, have consistently emphasized their individual skills to address errors. However, many experts (Uhlig, 2001; Merry and Brown, 2002) argue that human beings are prone to errors no matter how knowledgeable they are, and suggest systemic change to address medical errors.

Many scholars attribute this poor performance of healthcare organizations to their inability to manage operations (Mango and Shapiro, 2001; Thompson, Wolf, and Spear, 2003; Tucker and Edmondson, 2003; Green, 2004; Tucker, 2004). Some maintain that simple everyday functional tasks are still at their infancy in healthcare (Patel, Branch,

and Arocha, 2002). A medical practitioner even concludes that healthcare leaders have marginalized process innovation in favor of product innovation (Uhlig, 2001). In sum, lack of focus on work processes and its ultimate effect (operational failures) appear to have had a deleterious effect on the smooth functioning of the healthcare industry, ultimately exposing the patients to significant risks.

This is not to say, however, that healthcare leaders have remained oblivious to their industry's problem. Decades earlier, in order to fix the broken systems, healthcare leaders adopted different continuous process improvement initiatives such as the Total Quality Management (TQM), or Continuous Quality Improvement (CQI) but have met with limited success (Bigelow and Arndt, 1995; Westphal, Gulati, and Shortell, 1997; Blumenthal and Kilo, 1998; Shortell, Bennet, and Byck, 1998; Huq and Martin, 2001). They have also adopted Six Sigma (SS), another continuous improvement initiative, to address medical errors and to improve processes but its application has remained confined to very few healthcare organizations (Revere and Black, 2003; Torres and Guo, 2004). In short, systems in healthcare are still broken, and the industry needs a model to address them.

A third continuous improvement philosophy, lean manufacturing, also called Toyota Production System (TPS) as it originated in the Toyota Motor Company, has been gaining popularity in the U.S over the past 10 or so years because of its ability to produce the same output with a fraction of the organizational resources. Some scholars believe that TPS succeeds because of its relentless effort to eliminate waste in any form (Ohno, 1988; Shingo, 1989; Womack and Jones, 1996). Others (Sugimori, Kusunoki, Cho, Uchikawa, 1977; Cusumano, 1988; Krafcik, 1988) reason that Toyota succeeds because it uses specific tools indispensable for production. In a recent study, Spear and Bowen (1999) discovered that Toyota's success is not due to the specific tools. Rather they attribute its success to four TPS rules, three rules for designing work processes and the fourth rule for improving them.

Spear and Bowen's Design Rules

Spear and Bowen posit that Toyota designs production systems around three basic building blocks: activities, connections, and pathways. Each block is designed according to a rule, a so-called design rule. The building blocks can be construed as different types of routines for gaining maximum efficiency. The design rules provide guidance on how the three types of routines should be designed.

The first building block, an activity, is defined as work tasks that people or machines do to transform materials, information or energy. They argue that Toyota Motor Corporation or TPS driven organizations specify tasks to the minutest details leaving little room for confusion among the individuals executing it. In contrast, in a non-TPS driven organization, they find tasks not defined in sufficient detail, thus exposing the tasks to considerable variation during execution, affecting process outcome and product quality. Toyota specifies an activity in terms of four parameters: content, sequence, timing, and outcome. Content refers to the specific tasks within an activity. Sequence refers to the sequential order in executing the tasks. Timing refers to the time taken by individual tasks, and outcome refers to the results of the task. Spear and Bowen define Rule 1 as:

Rule 1: All work shall be highly specified as to content, sequence, timing, and outcome.

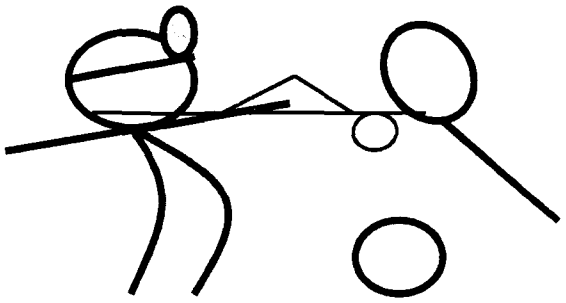

Figure 1: An Activity

The second building block, a connection, is the mechanism by which adjacent customers and suppliers transfer material, information, and energy. They find that Toyota emphasizes direct and clear interaction between the adjacent customer and supplier to communicate requests for goods and services and response to such requests. In contrast, in a non-TPS organization the requests for goods and services are not as direct or unambiguous like Toyota. Thus, Spear and Bowen define Rule 2 for connection as:

Rule 2 : Every customer-supplier connection must be direct, and there must be an unambiguous yes-or-no way to send requests and receive responses.

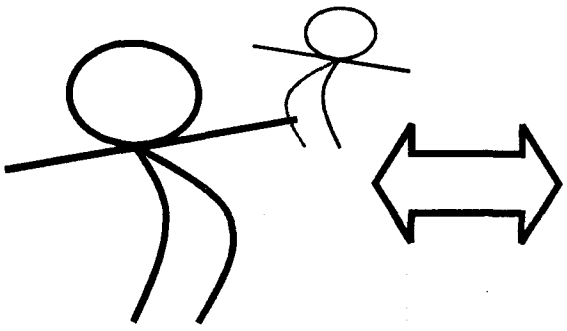

Figure 2: A Connection

The third building block, a pathway, is defined as a series of connected activities that create and deliver goods, services, and information. They observe that production lines in Toyota or TPS driven organizations are simple and direct. The product or service follows a designated path along its course from beginning to end. On the contrary, in non-TPS organizations, they observe that products often do not follow a specified path; rather, they move along a convoluted path depending on whichever resource is available to serve first. Thus Spear and Bowen define Rule 3 as:

Rule 3 : The pathway for every product and service must be simple and direct.

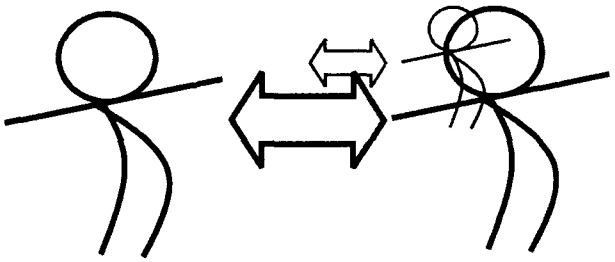

Figure 3: A Pathway

Spear and Bowen's (1999) research posits some basic principles to understand the inner working of routines better. What makes their study stand apart from others is that the design rules capture in sufficient depth the specificity that is needed in describing the inner working of a routine. Yet, they are simple to understand and are actionable in real world settings, suggesting that these principles are transferable not only across organizational boundaries but also across diverse sectors, thus alleviating the difficulties associated with transferring the best practices or routines to another setting. Moreover, the staff and the organization as a whole develop their own competency, capability, and independency to create their own routines using the design rules for gaining maximum efficiency and effectiveness instead of depending on others to transfer. This paper, therefore, presents just one of the many cases

on the application of the TPS rules in a mid-sized hospital in North America.

A Case Example

The Setting

The setting of this research was a mid-sized hospital in North-west America, with 146-bed and 1,245 employees. The hospital's net revenue was $114 million in year 2006. The hospital's top specialties are cardiology, obstetrics, pediatrics, and rehabilitation (including brain surgery). It also offers orthopaedics, emergency care, radiology, and general medical care. The number of inpatients per year is around 6800. It is one of the most modern best equipped hospitals in the region. The Joint Commission on Accreditation of Healthcare Organization (JCAHO) and the Rehabilitation Accreditation Commission (CARF) accredit the facility.

The Problem

It was in end 2003 that the problem of labeling specimens from operating room (OR) surfaced. The minutes of meeting on "Specimen Collection" held in March 2004 recorded that there had been some system issues in the process of collecting specimens (blood, body fluids, human tissues) from the OR and delivering them to the Laboratory (Microbiology, Pathology, Clinical) for diagnostic tests, and therefore, patients were at risk due to errors in the system. The matter assumed significance because patient care was at stake. Additionally, the Joint Commission on Accreditation of Health Care Organizations (JCAHO), a health care auditing agency, had very specific guidelines regarding laboratory work processes, and therefore, the director of laboratory wanted to identify problems that were creating areas of such non-compliance.

The Solution

A group of individuals from diverse functional departments in the hospital assembled to resolve the issue using the A3 Problem Solving Process (Jimmerson, Weber, Sobek, 2005), a problem solving technique grounded in Plan-Do-Check-Act (PDCA) approach or Shewhart's Cycle , adapted from Toyota, for use in healthcare. The A3 Process is encapsulated in 11" × 17" ledger size paper – called the A3 Report (Figure 4). The individuals represented laboratory, OR, Quality Risk Management (QRM), and Education departments. There were several other individuals who from time-to-time provided information and data to the problem solving team.

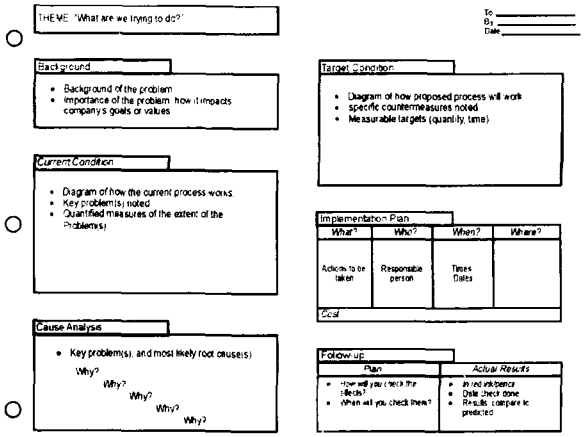

Figure 4: A3 Report Template

The A3 problem solving process succinctly called A3 Process requires direct observation of the problem. The logic behind observation is that when a person observes a problem s/he is more likely to address the problem objectively without any bias, communicate accurately with others leaving no room for apprehension, and seek a solution that would have an enduring effect. Additionally, direct observation provides valuable clues to problem solving.

In this case, a microbiologist decided to observe the problem first hand. She visited OR and spent 6 hours observing and 10 hours discussing with staff in OR. She watched several surgeries to understand the specimen labeling process. After observation, she drew the current state on the A3 Report for others to understand and visualize the problem. She also explained others on how the actual specimen collection, its labeling, and ultimately its transportation to the laboratory worked.

In the current state, i.e., prior to the A3 process, the surgeon collected the specimen (blood, body fluids, tissues) from the patient's body and gave it to a scrub technician (disinfected person who jointly works on the patient along with the surgeon and anesthesiologist during surgery). The scrub technician gave the specimen to the OR circulator (registered nurse responsible for the overall proceedings during surgery in the OR). The surgeon ordered the required tests on those specimens to the OR circulators. Occasionally, the interaction between the circulator and the surgeon suffered due to noise inside the operating room or for some other reasons. Consequently, the labeling by the OR circulator was sometimes not done correctly and contained errors. Sometimes, there were no labels (no patient name) or mislabeled (wrong patient name) on the specimen. On other occasions, wrong body site or wrong side (left vs. right) was mentioned. Occasionally, date and time of specimen collection were overlooked. The OR circulator then asked whoever was available at the time of surgery to bring the specimen down to the laboratory for tests. The person carrying the specimen was not always clear on the exact specimen and requests by the surgeons. Any questions from the laboratory staff were generally met with annoyance. The following data was collected to understand the magnitude of the problem.

Table 1: Surgery Specimen Labelling (Before A3 Process)

	April 2004
Patient's Name	100%
Source	100%
Date	50%
Time	33%
Circulator's initial	50%
Ext# for contact	22%
Sample #	36%
N	36

Inadequate labeling led to unnecessary phone calls, billing errors, frequent disputes between OR and laboratory staff, delays in reporting results, poor patient care, and sometimes liability issues. In essence, the current state was exceedingly prone to wastes and errors.

In order to understand the root causes to the problem the group followed the "5-Whys" approach. The root cause after brainstorming revealed that ignorance of the OR staff about the implications of mislabeling and how it affected the working of the downstream departments. Indeed they lacked clear understanding of what entailed successful specimen labeling and how to successfully transport specimens to other functional departments.

To circumvent the problems, the problem solving team had a series of discussions with the director and the manager of OR and the target state was drawn on the A3 Report. The new agreed upon process was then implemented in OR with immediate effect. In the target state, the surgeon collected the specimens from the patient's body and handed them over to the scrub technician. The scrub technician forwarded the specimens to the OR circulator. The surgeon ordered the tests for the specimens verbally to the OR circulator. The OR circulator verified all pertinent details regarding that

specimen from the surgeon upfront before accepting it. She filled out all the details as required in the newly developed printed labels. The label captured information such as 'patient ID', 'specimen source', 'date', 'time', 'initial of the OR circulator', 'ext #', and 'sample #'. She then handed over the specimen along with the label to a designated transporter. The designated transporter brought the specimen immediately to the laboratory, if it required immediate freezing. Otherwise, s/he transported the specimens every two hours. The laboratory performed the tests and sent the results to the surgeon concerned timely.

The new process came into effect in the month of April 2004. Following implementation, follow-up data were collected at regular intervals to measure the efficacy and sustainability of the new process. The following table presents the follow-up data.

Table 2: Surgery Specimen Labelling (After A3 Process)

	May 2004	June 2004	Sep 2004	Jan 2005
Patient's Name	100%	100%	100%	100%
Source	100%	100%	100%	100%
Date	75%	67%	100%	94%
Time	61%	89%	73%	92%
Circulator's initia	81%	86%	85%	92%
Ext # to contact	42%	30%	54%	92%
Sample #	64%	30%	54%	92%
N	36	36	36	36

Discussion

This simple case reveals that the steps in the specimen labeling activity in the OR were only touched upon (a poorly specified activity) thus defying Rule 1 of TPS (specified activity). As a result, OR staff lacked clear understanding about the information need by the laboratory. This absence of clearly defined tasks such as providing the right patient's name, providing the specimen source, date of collection, time of collection and so on led to multiple errors and subsequently delays in testing and ultimately reporting the results.

The interaction or connection among the individuals inside the OR (circulator and surgeon, circulator and the individual transporting the specimen) was ambiguous thus violating Rule 2 of TPS (unambiguous connection). There were gray zones in deciding who brought the specimen to the laboratory for testing. In fact, there was no designated transporter before the problem solving process. As the transporter was not a fixed person s/he did not have any clue about the specimens and failed to answer queries posed by the laboratory staff regarding specimens. Consequently, the laboratory staff had to make multiple phone calls to the OR to find the necessary details about the specimens and what tests the surgeons needed. Absence of poorly defined specimen labeling activity and ambiguous hand-offs or connections between individuals during delivery of specimens led to convoluted pathways thus defying Rule 3 of TPS (simple pathways). In sum, patient care delivery process was at stake and conformance to JCAHO standards became difficult.

The team corrected the situation by clearly specifying the specimen labeling activity (furnishing specific information sequentially on the labels before dispatch). It also ensured direct connection between individuals (circulator and surgeon, circulator and a designated transporter, designated transporter and the laboratory staff) about a) who would make the request to whom, b) what information is needed, and c) how the recipient of the request would respond. Consequently, by specifying the labelling activity and creating direct hand-offs between individuals in the process chain led to simplified pathways and eventually quick

turnaround time of laboratory results for timely patient care. This simple case demonstrates how TPS design rules could be beneficial in constructing simple but efficient work system in a hospital setting. The author applied the rules in several clinical and non-clinical areas in the hospital and observed absence of one or more design rules in every failing process. The rules are very generic in nature, and therefore, have general applicability to many work systems in healthcare and beyond.

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About the author:
Manimay Ghosh *is an Associate Professor in Operations Management at IMT, Nagpur. He can be reached at mghosh@imtnag.ac.in*