Applying the Toyota Production System to a Hospital Pharmacy

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Abstract

This paper presents the early results of an action research project to apply the principles of the Toyota Production System to a hospital pharmacy. We demonstrate that work systems can be improved through Bowen and Spear's [3] Rules-in-Use: defining activities better, making simpler and more direct connections, and/or smoothing pathways. We also extend this work by introducing a problem-solving tool to facilitate process improvement. The paper will describe the interventions attempted, the results, and implications for applying the Rules-in-Use to health care environments.

Keywords: Toyota Production System, health care, lean manufacturing

1. Introduction

The Toyota Production System is perhaps the most powerful model devised to-date for efficient design and management of large-scale operations. This system helped propel Toyota Motor Corporation from a small truck-maker struggling in the wake of World War II, to the world's third largest automaker by the end of the 1980's [1]. Many Japanese manufacturers copied Toyota's production system, or TPS, and after several decades of refinement it has became known as the "Japanese approach" to manufacturing, later dubbed *lean manufacturing* because of its ability to do so much more with fewer resources than traditional approaches [2]. In recent years TPS philosophies and practices have been transferred to many manufacturing facilities in the US and around the world with such success that "lean" is rapidly becoming the dominant manufacturing paradigm.

While this approach to manufacturing has been wildly successful, for the most part it has not left the factory walls. One can find few cases where this model has been applied to other sectors. We hypothesize that transferability has been difficult because research on lean manufacturing has yielded either high-level goals that are not actionable, or descriptions of practices/tools that are finely tuned to the context of high volume, discrete manufacturing and not applicable to other environments.

Recent research at the Harvard Business School, however, may have uncovered a set of principles for TPS that are specific enough to drive action, yet general enough to apply to multiple contexts [3]. We are conducting an action research project on how this incredibly powerful model of operations management can be applied to one of society's most important sectors, and one that in this country is in crisis—the health care industry. In this paper, we report on the results of recently completed pilot study in a hospital pharmacy. The following section provides background information on the Toyota Production System and its impact on manufacturing. Section 3 presents the research arguments in more detail, and then section 4 describes the pilot study. The final section concludes the paper with initial insights into the research questions, implications, and next steps for the pharmacy.

2. Background

In the mid-1980's, American manufacturing was in crisis [4]. Many US companies found themselves losing market share to a set of Japanese rivals they had earlier dismissed as second-class manufacturers. Higher quality, lower cost

products were flooding the marketplace, and American consumers were flocking to them. US manufacturers responded by placing renewed emphasis on understanding their customers' needs and improving product quality in ways meaningful to the customer [5]. The quality of US goods improved, and costs were reigned in, but the Japanese still seemed to outpace their American competitors.

Numerous researchers traveled to Japan to discover the secret of their success. In perhaps the most well known of these studies, a team of MIT researchers described an entirely different system of production—so new and innovative, in fact, that they gave it new name, "lean manufacturing." The term was coined because this system produced goods with higher quality at half the cost and in half the time of traditional manufacturing methods [2]. Since then, US manufacturers have been adopting lean manufacturing practices with astounding success (e.g., [6]): productivity improvements in the triple digits, defect rates falling by orders of magnitude, increased customer satisfaction, greatly reduced employee turnover, and other claims.

2.1. Lean Manufacturing

Academics and practitioners typically describe lean manufacturing on two levels. At a high level, it is a philosophy, a perspective that abhors waste in any form, relentlessly strives to eliminate defects, and continually attacks both in a never-ending pursuit of perfection (e.g., [7]). Most descriptions of lean manufacturing, however, quickly move beyond the philosophical to an interrelated set of practices that range from overall material flow in the factory to detailed work and equipment design to human resource practices (e.g., [8, 9]). The aims of TPS are to use as few resources as possible (labor, material, and space) to produce the desired amount of product at the highest possible level of quality. The result is a mass production system that produces quality products with minimal cost.

Strangely, despite the power to greatly improve organizational operations, these ideas have not been easily transferred [6]. Many of the companies that report significant gains from lean implementation often find that the improvements remain localized to a given product line or plant—the company is unable to transfer the learning to other parts of the company [10]. We argue that the reason TPS (or lean) has not moved much beyond plant floor is that it has not been sufficiently studied to render what Argyris [11] calls actionable principles. The lean philosophy in the forms often espoused—eliminate waste, root out defects, reduce lead times, etc.—is well and good, but not actionable (e.g., what is 'waste'? How to find it? If found, how to eliminate it?). The practices associated with lean manufacturing do provide quite specific implementations, but the tools are specific to the situated practice of discrete manufacturing. They are so heavily context specific that they cannot be transferred successfully without significant modification, if at all.

2.2. Actionable Principles of TPS

Even though lean manufacturing is often described as a Japanese phenomenon, in fact the philosophy behind lean manufacturing and the integrated set of practices required to implement it, were invented by Toyota Motor Company [1]. Some recent research holds promise of identifying actionable principles from the Toyota Production System (TPS). Spear and Bowen [3] note that the truly innovative aspect of TPS is not the individual practices, but rather the processes by which Toyota designs its production system—that is, how it has and continues to innovate new practices—and the principles guiding these design decisions. They observe that TPS experts define production systems in terms of "activities," "pathways" and "connections." System design decisions attempt to streamline pathways and make direct connections between activities with simple, binary communications. The practices so thoroughly documented in the literature are just simply some effective ways, proven over time, of streamlining pathways and making connections direct. These define the first three Rules-In-Use: 1) specified activities, 2) direct binary connections, and 3) smooth pathways for the delivery of goods and services [3].

The fourth rule-in-use is to implement system changes following the principles of testability in Descartes' Scientific Method [3]. Any improvement must be made in accordance with the scientific method, under the guidance of a teacher, at the lowest possible level in the organization. Every piece of the system is predicated on a testable hypothesis of the operation's expected results, such that results different than expected are made readily visible and countermeasures can be taken. This explains why standardized work is so critical to the system. Every time an improvement is proposed, the proposal explicitly states the expected outcome (i.e., a hypothesis) that can be verified or refuted through experimentation (i.e., actually doing the work).

3. Research Questions

Since one can find few (if any) documented cases of TPS implementation that are not closely tied to manufacturing, it appears that little research has been done on the transferability of this operational system beyond manufacturing. Our work addresses this gap. Specifically, we want to apply the Rules-In-Use to a non-manufacturing sector.

One would be hard pressed to find a more compelling sector than health care in which to do this. The US health care system is half again more expensive than any other country, with health care expenditures projected to meet the $2 trillion mark (roughly 16% of gross domestic product) in the next few years [12]. While some may argue that the US has the best health care in the world, customers are increasingly dissatisfied with the quality of care. An Institute of Medicine report [13] estimates up to 98,000 avoidable deaths occur annually in the US due to medical error. In addition, employee turnover at most hospitals is a major concern, with all areas of the country facing nursing and technician shortages. The industry has responded in similar ways as manufacturers did when facing crisis—focusing on total quality management and meeting/exceeding customer satisfaction. Most hospitals today have quality improvement programs and departments in place to take on quality initiatives. Such efforts have been successful in increasing the customer awareness of their employees, and having some impact on error reduction, cost reduction, and patient satisfaction [14]. But the methods used are generally focused on the care; they often do not address organizational systems well, and are not responsive to the needs of the caregivers [15].

Thus health care seems ripe for the next step. Additionally, improving health care quality while reducing costs and improving responsiveness is consistent with the goals of TPS. Both want to exactly match resources to need—too little resource will not satisfy the need, too much is waste. Both want fast response—to get from 'need' to treatment as quickly as possible is akin to getting from raw materials to finished product. Both want to deliver a product free of defects/errors. With goals so well aligned, TPS and health care seem a natural fit.

Our work, then, attempts to answer the following questions: 1) Can the principles of the Toyota Production System improve health care delivery? And 2) if so, what implementation strategies are more likely to lead to success? Our first step was to conduct pilot studies in two units at Community Medical Center, a mid-sized hospital in Missoula, MT. This paper reports on the second of those pilots, conducted in the hospital pharmacy.

4. Application to a Hospital Pharmacy

The pharmacy at Community Medical Center (CMC) is responsible for filling medication orders for all hospital inpatients, and delivering them to the proper hospital unit. At the time of our study, the pharmacy also ran a retail window for outpatients and hospital employees. The pharmacy operates around the clock with a staff of about 28 people (15 pharmacists, 9 technicians, 3 interns, 1 director). The department processes about 500 new medication orders per day for inpatients alone. Administratively, all personnel report directly to the pharmacy director, who reports to the vice president of patient care. The pharmacy was chosen as a study site because CMC senior management was concerned about medication error rates, perceived low levels of service and responsiveness among other departments towards the pharmacy, and inventory costs substantially higher than the industry norm.

4.1. Data Collection and Observation

An undergraduate research assistant spent 10 weeks in the summer of 2002 assisting the pharmacy with TPS implementation. Her first task was to observe and document the operation; that is, what are the activities and the series of connections that make up the key pathways in the department? To do this, she focused her efforts on the inpatient order processing function, and created a value stream map [9] of the medication order filling process. The value stream map depicts all the value-added steps and waiting times of the process that delivers the good/service (i.e., the pathway), along with planning and control information flows associated with that pathway.

The detailed and extensive observation of actual work processes required in making the value stream map produced two key insights. The first is that the medication order pathway was complex. A medication order could take multiple pathways through the department when more than one pharmacist was one duty, usually the case during the high volume times (8:00 a.m. – 6:00 p.m. weekdays). This violated Rule #3. The system redesign and implementation results are described in Section 4.2.

The second insight was that pharmacists were constantly interrupted as they tried to do their work. Many of the interruptions seemed to be phone calls from other units in the hospital to check on, clarifying, change, or ask for

more instructions on an order. The phone calls interrupt the flow of orders through the department because the pharmacist stops order processing to field the phone call. To better understand the extent of the interruptions, the pharmacists noted every phone call, its source, and reason for call for 7 days using a data collection form. The research assistant then coded the data and discovered that a pharmacist may field as many as 10 calls per hour, and that 25% of all calls concerned "missing medications." This label applies to any situation where a hospital unit expects a medication to be in a certain location at a certain time in a certain dosage, and it is not. Since "missing medications" accounted for the largest portion of calls among the categories noted, we decided to investigate the root causes of some of them to see if we might be able to design better connections between hospital departments. These efforts and results are described in Section 4.3.

4.2. Dedicated Order Entry Pharmacist System

The inpatient order filling process begins when an order arrives, usually by fax (see Figure 1). A pharmacist picks up the order and enters it into a medication administration software system. Once entered, a set of labels prints in the inventory area. A technician picks up the labels and uses them to pick the medications from inventory. The technician packages the medications and applies the labels, then sets them aside for checking. Since a technician picked the medication from inventory, a board certified pharmacist must check the order before it is delivered. If all checks out fine, the order is sent by vacuum tube to the unit that placed the order. The value stream analysis revealed that the steps from order to delivery represent about two minutes of work per typical medication, but it takes approximately 38 minutes on average from order to delivery.

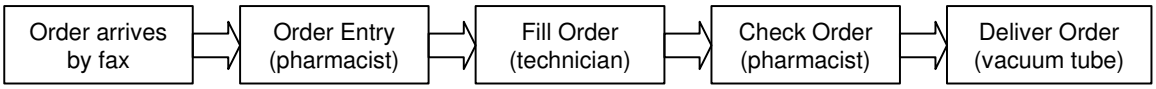

Figure 1: Medication Order Processing for Inpatients

During the busiest times, two pharmacists are on duty to process inpatient medication orders. In the existing system, either pharmacist could process a new order—whomever saw the order first and wasn't called away to something else. Likewise, either pharmacist could check an order that was ready to go. This meant that the pharmacists' activities were not specified; once completing a task, s/he had to look around to see what to do next, resulting in unnecessary idle time and sub-optimal performance. If a phone call came in regarding an order, either pharmacist might answer it, and it would not be clear who should the get the phone call because one would not know if the order had not yet been processed or was processed by the other pharmacist, without some level of investigation. Thus any phone call had the potential to interrupt not just one, but both pharmacists!

A pharmacist volunteered to work out a dedicated order entry pharmacist system (with the research assistant) to simplify the medication order pathway. In the redesigned system, whenever two pharmacists are on shift, one pharmacist processes orders and takes phone calls only if the call is to clarify an order. The other pharmacist checks orders, answers phone calls, and handles all other duties so that the order entry pharmacist can process orders without interruption. The pharmacists trade places in the afternoon. The idea was documented, communicated to staff in face-to-face meetings with the volunteer pharmacist, and tried out on several shifts. The average number of orders-in-system dropped 32%, with a corresponding drop in order-to-delivery time. (The average number of orders-in-system was estimated using work sampling.) The pharmacists using the new system also reported less stress and franticness in carrying out their responsibilities.

This result is quite interesting as one might predict the opposite effect due to pooling of resources. If both pharmacists are available for order processing, for example, then one might expect fewer orders waiting to be processed. However, the added complexities of such a system (e.g., communicating about who should take a given phone call) seem to mitigate any pooling effect. The results seem to substantiate the Toyota principle: simplified and direct pathways lead to better operational performance.

4.3. Missing Medications Problem-Solving

We took a different approach to the missing medications issue identified in the phone call interruptions study. The research assistant began picking up newly generated missing medication problems, and retracing steps to find the root cause of the problem. To do this, the research assistant used a tool called the "A3 Problem-solving Report," so called because it fits on an 11x17 inch sheet of paper, roughly equivalent to the A3 size by European standards. The A3 report is an adaptation to a similar tool Toyota uses in problem solving. The report's author starts by stating the

problem and drawing a representation of the current state of the system on the left side of the report, with problems identified as storm clouds. Directly below the current state is a root cause analysis of the key problem(s) identified, using a suitable approach such as the 5 Why's method. (Interestingly, every root cause analysis we've done has discovered a poorly designed connection, an unspecified activity, and/or a complex pathway at its root.) The right side of the report begins with a depiction of the target condition of the process, with countermeasures proposed. Directly below that is an implementation plan indicating the steps needed to realize the future state, when they will be done, and who is responsible. On some reports, we have included measurable cost/benefit data to show the magnitude of the proposed improvement. The report concludes with a follow-up plan, and space reserved to report follow-up results.

One source of missing medication errors concerned those requiring refrigeration. The nurse would see the medication listed on the physician's orders, but not see it with the rest of the medications. She would immediately call in a missing medication. Further investigation revealed that the medication was delivered on time, but stored in the department's refrigerator, not with the rest of that patient's medications. Without more knowledge about the medications, the nurse could not know to check the refrigerator. This is clearly symptomatic of a poor connection regarding this medication type. The countermeasure implemented was a bright pink card labeled "refrigerated med" that would go out from the pharmacy with any medication requiring refrigeration. When the medications are delivered, and one is placed in the refrigerator, the card would be placed in the normal delivery location to notify the nurse unambiguously that a medication is waiting in the refrigerator.

Another set of missing medication notifications resulted from so-called amended orders. Occasionally, a physician will fill out his/her orders (including medication orders), and then later, after the original order had been faxed to pharmacy, decide to add one or more medications. Under the existing system, when the pharmacist received the appended order by fax, s/he may not notice the appended items and either fills a duplicate order (waste of resources!) or assumes it's a resend and does not fill it, resulting in the missing medication. (Apparently, it is common for some units to resend medication orders if they feel an order is taking too long to arrive. So the pharmacy is accustomed to ignoring orders that are apparently resent.) This situation shows how an activity that is not specified (i.e., how to handle amended orders) results in a poor connection between the two parties. The countermeasure implemented was a rubber stamp that reads "ORDER FAXED. Additional orders below this line" which is to be stamped immediately upon faxing a medication order to the Pharmacy. All hospital units now use this stamp. This countermeasure simultaneously makes it clear to physicians and other medical staff how to handle amended orders, thereby specifying the activity, and makes the connection with the pharmacy more robust as it is visually clear which medications have been added to the order since the original sending.

A third source of missing medications discovered was in the intravenous (IV) medication area. An expensive nutritional supplement (called TPN) would be ordered on a 4-hour cycle. However, unbeknownst to the pharmacy staff, the nursing staff must sometimes stop the TPN if the doctor orders another medication. This puts the TPN drip off cycle, but the pharmacy would still deliver the medication according to the original schedule. Since the TPN has a short expiration (a matter of hours from the time the formula is made up), it may have to be destroyed for passing the expiration time, resulting in an apparent missing medication. Again, lack of specificity in handling these TPN orders resulted in poor connections and productivity losses to the organization. The short-term countermeasure was a notification system to the pharmacy whenever a TPN drip is stopped. The long-term countermeasure was to use dual-line IV so that the TPN drip would not have to be stopped to administer another medication intravenously.

These and other initiatives to identify the root cause of missing medication phone calls and implement countermeasures to prevent recurrence resulted in a 40% decrease in missing medication notifications over a one-month period, from 24 per day to 14 on average. It seems that making clear, ideally binary, and direct connections between departments contributes to better operational performance. The study also made it clear that many errors in medication delivery were not the result of any one department's failings, but were due to system failures; or, more specifically, from failure of management to design simple, robust, effective operational processes.

5. Conclusions

The pilot study results have answered, at least to some degree, our first question. The four Rules-In-Use can be applied to a health care setting to improve the reliability and effectiveness of health care delivery systems. We have

also discovered that the principles work well, even though they may seem counterintuitive. The effectiveness of the principles seems to be their ability to guide the organization in simplifying processes without compromising them.

The work has also extended Spear and Bowen's work. First, we've adapted a tool from Toyota to help with problem solving. The tool has the scientific method embedded in it, along with sound problem-solving approaches. We have demonstrated its usefulness on several accounts. Second, we are learning much more about how to enact the fourth rule. For example, it seems crucial that the problem-solver not be a "consultant" from outside the department, but someone who has a real stake in the outcome in terms of their daily work, and who can properly build the consensus for the proposed change.

Many challenges lie ahead for the pharmacy to continue along this path of improvement. The first is, now that the research assistant is not there to assist with data collection, how will the organization find time to do the problem solving and system redesign work? Second, only one or two individuals from the department were really involved with the changes. How can the department get a critical mass of people trained up and on-board? The third challenge is that many of the "problems" experienced by the pharmacy are in its relationships with other departments, and often the best answers lie in changing how work is done in other departments. How to accomplish this can be a delicate matter. Finally, perhaps the biggest challenge is to move away from the fire-fighting, quick fix mentality so prevalent in health care, and to begin to think about the system and how the system can be improved. Fortunately, the TPS principles and tools are designed to help organizations do just that.

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