PRAGMATIC PROBLEM-SOLVING FOR HEALTHCARE: PRINCIPLES, TOOLS, AND APPLICATION

Manimay Ghosh and Durward K. Sobek, II
Mechanical and Industrial Engineering Department,
Montana State University, Bozeman, MT 59717

Abstract

There is a growing national concern that health care organizations do not have a sound operating system in place. Reforming the operating system has assumed significance because of increasing operating costs and diminishing reimbursements from the payers. Critics argue that in the last 100 years or so significant strides have been made in product innovation but very little in process innovation. In an effort to improve the internal systems, health care leaders have adopted various process improvement techniques, yet success has remained elusive in most of the cases. The Toyota Production System (TPS), built on basic Industrial Engineering principles, offers powerful tools to revamp health care's work processes. Its application in the health care sector has been limited despite showing signs of promise. The authors present a successful application of TPS design rules, using a problem solving process adapted from Toyota, in improving the group meal therapy process in a Rehabilitation Nursing Unit (RNU) of a hospital. They present how participants observed the problem first hand, did root cause analysis, and then used the TPS design rules to redesign the process, which dramatically improved the patient outcome and productivity of the therapists.

Keywords

Toyota, healthcare, process improvement

Introduction

Health care has become one of the foremost domestic issues in U.S. Health care spending was around $1.8 trillion in 2004, represented 15.5% of the gross domestic product, and is expected to climb to $3.4 trillion, or 18.4% of gross domestic product by 2013 (Biotech Week 2004). Health care costs are increasing by leaps and bounds (Industry Week 2004), and yet the service has been far from satisfactory. Murphy Leadership Institute in 2003 studied 71 hospitals and reported that 35% of employees' time was wasteful, i.e. the work that did not add value to the patients or other customers. Many argue that poor service in health care could be attributed to inefficient work processes (Tucker 2004; Thompson et al., 2003; Tucker and Edmondson, 2003). In an effort to improve the internal work processes, health care organizations, over the years, have adopted various process improvement techniques such as Total Quality Management (TQM) and Six Sigma (SS) to reduce high costs, wastes, inefficiencies, and poor care but success has remained elusive in a majority of the cases.

TPS has been in existence in the manufacturing sector for five decades or more and has been widely hailed for its ability to produce the same output with lesser resources (less material, less labor, less machinery). Despite its success in the manufacturing sector it has found limited acceptance in the non-manufacturing sectors of the economy. Some experts believe that TPS succeeds because of its relentless effort to eliminate waste in any form from the system (Shingo, 1989; Ohno, 1988). Yet another group of experts attribute the success of Toyota to its deftness in managing a wide range of low cost production tools (Cusumano, 1988; Krafcik, 1988) to produce high quality products. In a recent study, Spear and Bowen (1999) discover that Toyota's success is not due to the low cost tools mentioned earlier. Rather they attribute its success to four principles or so-called Rules-In-use (we call the first three "TPS design rules" in this paper) that it uses in designing work processes.

Even though TPS is widely accepted as the most efficient production system developed to date, its application outside manufacturing is scarce. In fact, to our knowledge, it has very recently been applied in health care (Thompson et al., 2003; Sobek and Jimmerson, 2003; Jimmerson et al., 2005; Spear 2005). The focus of this paper is on demonstrating the applicability of the TPS design rules in improving work process in a hospital setting.

In the next section we briefly discuss the different process improvement techniques, TQM, SS, and TPS adopted by health care industry prior to TPS.

Background

Total Quality Management

Adoption of various quality initiatives is not new to health care. In fact, TQM, also known, as Continuous Quality Improvement (CQI) was first adopted by health care in the late 1980s (Westphal et al., 1997) to improve operational performance and patient care. At the high level, it is seen as scientific approach: Plan, Do, Check, and Act, often called PDCA. At the operational level, it is armored with seven conventional statistical quality control (SQC) tools: Scatter Diagram, Histogram, Control Chart, Run Chart, Pareto Chart, Flow Chart, Cause and Effect Diagram; and seven management tools: Affinity Diagram, Interrelationship Diagram, Tree Diagram, Matrix Diagram, Matrix Data Analysis, Arrow Diagram, and the Process Decision Program Chart.

Management literature on TQM is rife with articles (Blumenthal and Kilo, 1998, Shortell et al., 1998; Zabada et al., 1998) that present arguments on why TQM or CQI had little impact in reforming health care organizations. These authors cite lack of physician support, absence of organizational structure and culture as possible causes for failure. Some other authors observe that CQI had limited positive impact in health care because it was very time consuming and costly (Revere and Black, 2003; Ovretveit, 1997). And a few others find that many health care professionals had difficulty with the interpretation of the PDCA process and the problems were usually addressed by senior level professionals only and thus front-line staff were left out of the problem-solving loop (Walley and Gowland, 2004). In short, TQM had limited positive impact in transforming health care organizations due to organizational and procedural issues.

Six Sigma

SS is a statistics based structured problem solving approach imported by health care from industrial sector in the late 1990s to reduce variability and errors in work processes and also to improve operational performance. At a high level, SS is a five-step process - define, measure, analyze, improve, and control commonly abbreviated as DMAIC. At the operational level, it is a package of standard tools of TQM and a wide variety of advanced statistical tools i.e., Hypothesis Testing, Confidence Intervals, Multivariate Analysis, Design of Experiments, and Regression Analysis and so on.

Some experts (Revere and Black, 2003; Torres and Guo, 2004) report that few health care organizations have adopted SS. Benedetto (2003) notes challenges and obstacles in implementing SS in the project site he worked. It is a heavily data driven process but managerially useful data was difficult for him to obtain and therefore he depended on manually collected data. Front line employees had a difficult time understanding the SS tools and concepts as few had education beyond high school, and therefore, had little exposure to statistics. They also had problems dealing with the multi-step process of SS. Furthermore, SS requires a base line performance to improve. But absence of standard operating procedures made his task even more challenging. Finally, his project was constrained by institutional resources. Some of the difficulties reported by Bendetto (2003) have been documented in other trade literatures as well.

Apart from the procedural difficulties, most SS projects discussed in the literature report on projects handled mainly by senior level professionals or by Black Belts, who essentially hold managerial positions in the organizations. In sum, SS's successes in healthcare have been slow and limited due to procedural difficulties as well as due to paucity of institutional resources.

Toyota Production System

Many researchers, academicians, and practitioners regard TPS (dubbed lean manufacturing) as the most efficient production system devised to date. Several studies in the 1980s have shown that Japanese firms led by Toyota have achieved the highest levels of efficiency (Cusumano, 1988) and the trend continues unabated (Wall Street Journal 2004).

TPS is construed in the manufacturing literature at various levels. At the philosophical level it is a system that drives waste out of the system (Shingo, 1989, Ohno, 1988). At an operational level it is viewed by others as the system that harnesses various low cost production tools such as kanban method, just-in-time (JIT), production leveling (heijunka), set-up reduction, Poka-Yoke, standardized work and so on. Spear and Bowen (1999; 2004) have researched Toyota work practices over an extended period of time and argue that Toyota's success is not due to the use of low cost tools discussed above. Rather, the success of Toyota could be attributed to the process by which Toyota designs its work processes. Toyota's design of work processes is grounded in four principles or rules. The first three rules are used by Toyota or TPS driven plants to design work processes and the fourth rule involves systematic problem solving. What makes these rules or principles so powerful and appealing is that they are simple and actionable in the real world settings because process improvements in Toyota or TPS driven plants are initiated and carried out by front-line staff under the guidance of a supervisor. Furthermore, these principles do not appear to be peculiar to high volume, low variety manufacturing concepts.

TPS Rules-In-Use

Spear and Bowen (1999) observe that Toyota designs its production systems in terms of three parameters: "activities", "connections", and "pathways". Each parameter is designed according to a rule. The fourth rule involves making improvements in work processes through systematic problem solving.

The first parameter, an activity, is defined as work tasks that people/machine 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 non-TPS driven organizations, 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 work 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, "All work shall be highly specified as to content, sequence, timing, and outcome."

The second parameter, a connection, is the mechanism by which adjacent customer and supplier transfer material, information, and energy. They find that Toyota emphasizes direct and clear interaction between 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 as, "Every customer-supplier connection must be direct and binary."

The third parameter, 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 till end. On the contrary, in non-TPS organizations, they observe that products often do not follow a specified path; rather moving along a convoluted path depending on whichever resource is available to serve first. Thus Spear and Bowen define Rule 3 as, "The pathway for every product and service must be simple and direct."

The fourth rule involves scientific problem solving. Spear and Bowen define Rule 4 as, "Any improvement [that] must be made in accordance with the scientific method, under the guidance of a teacher, at the lowest possible level in the organization." Every improvement made with the rules are considered as an experiment and the results of the improved process are compared against a pre-determined standard to check its efficacy.

These rules provide the necessary direction to a system to move toward ideal. Though the term ideal is not easily attainable, yet it provides Toyota and TPS driven organization to continually focus their efforts in that direction. They define an ideal output to be defect free, delivered one-by-one, on demand, immediately, with no waste of resources in an environment that is physically, emotionally, and professionally safe for employees. Interestingly, this conceptual notion of ideal could be applied to any industry and ideally suited for to healthcare environment where individuals struggle to provide such service consistently.

The setting

The TPS study at Community Medical Center (CMC), Missoula was a joint project between CMC and Montana State University (MSU) from 2001 to 2004, funded by the National Science Foundation. CMC is a 146-bed acute-care facility in Missoula, Montana offering services in pediatrics, cardiology, obstetrics, surgery, neonatal intensive care, rehabilitation, radiology, nuclear medicine, and general medical care.

Prior Work

The project of investigating the role of TPS started in 2001 when Durward K. Sobek, II, Associate Professor-Mechanical and Industrial Engineering and Cindy Jimmerson, a RN with 30 years of experience in trauma care first introduced the principles and concepts of TPS as propounded by Spear and Bowen (1999) to the staff members in CMC.

In the initial stages of the project, they realized that CMC was rife with people issues. The manpower turnover was high. There was a growing shortage of manpower in every functional area. As a result, many existing employees were compelled to work long hours in discharging their basic day-to-day responsibilities, and therefore, had very little time for process improvement activities.

Since the traditional tools (i.e., KANBAN, Single Minute Exchange of Die, Just-In-Time) of TPS were not easily transferable to health care and people have very little time for actual problem solving, Sobek and Jimmerson mobilized just two tools: Value Stream Map and the A3 problem solving report. First, they used the Value Stream Map, a visual tool that focuses on the total system and identifies the value added and non-value added activities. Next, they adapted the A3 report, a tool from Toyota Motor Corporation, modified it, and created a template on one side of an 11"×17" paper for simplicity and convenience. Later they demonstrated how the A3 report aided the fourth rule of TPS i.e. scientific problem solving. They coined the term A3 problem solving process. They also attempted to solve process related problems in the Pharmacy and the Montana Heart Center using the A3 problem solving process and report.

The first author of this paper joined the team in mid-2003 and initially coached the staff in CMC on TPS design rules, A3 problem solving process, and A3 report. He later conducted action research using A3 reports in diverse areas of CMC: Patient Financial Services, Hospital Information Management, Emergency Room, and Registration etc. The authors, in dozens of sites (clinical and non-clinical), have successfully analyzed the poorly performing work processes using the A3 process and report, and have reconstructed them using the TPS design Rules-In-Use. They have noticed absence of one or more design rules in all failing processes. The results after reconstruction have been very encouraging and have given them the hope and the confidence that TPS may be applicable in health care.

As the process improvement exercise started rolling in CMC, the staff became actively involved in solving problems on their own in clinical and non-clinical areas of the hospital. The following case is one example of the problem solving effort by a speech language therapist in RNU.

The Case

The RNU department at CMC provides assistance to patients with swallowing problems through group meal therapy program. However, the entire therapy process was surmounted with varieties of problems, which led to low productivity of the therapists and poor patient care. The problem solver, who initiated this project thought it to be a small problem initially, but as she started delving into it, she found it to be a problem of much bigger magnitude. So, she invited staff from different functional disciplines (occupational therapy, scheduling, speech therapy, nursing, and secretarial) to participate in the A3 problem solving process. She felt, “everybody had his or her piece to contribute.” In all, around 50 people participated in the A3 problem solving exercise.

The A3 Problem solving Process

The first and foremost step in A3 problem solving process is to observe the current state of the process and then diagram it with a pencil on the A3 report with appropriate icons and arrows. Observing the problem not only provides objectivity to the understanding of the problem but also ensures accuracy in the information. Diagrammatic representation of the current state on one hand captures the tacit understanding of a group of individuals and on the other explicates the problem very concisely and effectively. The freehand sketch overtly appears simple but captures dense information, and yet lucidly. Diagramming with a pencil fulfils the need for revising the sketch to represent the collaborative understanding of the problem. In this case, the problem solver as well as other therapists observed the group meal therapy process as they happened and calculated how much time each task took. She corroborated her findings with the findings from other therapists.

In the current state, the therapist collected schedule from the scheduler and the patient chart from the shelf. S/he then brought one patient at a time from each individual room to the common area, as there was no fixed rule as to who will bring the patients to the common area. S/he then looked for supplies (wash cloth, tape, thickener, straw) needed during therapy, which were kept in different places. Since they were not kept in designated locations, s/he had to contact multiple caregivers (nurses, techs) for their whereabouts. After assimilating supplies, s/he also collected food trays for the patients. On completion of the prepping, the treatment started. During the treatment session, the therapists were often not clear about the goals (feeding, positioning, swallowing, cognition, and communication) that needed to be achieved. Consequently, a lot of inconsistencies existed from one therapist to another as how to treat a patient. So s/he had to call other therapists for assistance, and in some situations, the necessary goals were not met.

After the treatment, there was confusion regarding clean up and returning patients to their individual rooms, causing multiple unwanted communications among therapists, techs, nurses, and the secretary. The therapist even had to sometimes return the patient back to his/her room.

As the set-up time, charting time, and clean up time accounted for almost 50% of the total therapy time (45 minutes), the therapists were able to bill for just 50% of their actual patient care time, on average. In addition, as the therapists were busy prepping, they could not offer the foods to the patients on time, which resulted in cold food for the patients, when offered. In essence, there was a perpetual dissatisfaction among the patients and therapists with how the process worked.

Sarah Elliott, in consultation with others, hand sketched the current state on the left hand side of the A3 report (see figure 1). She drew storm clouds, or problem areas near the current state, which showed lost productivity of the therapist, lost charges (50%) for the procedures, inconsistent treatment levels among the therapists, and cold food for the patients.

The A3 process requires brainstorming among the participants to find the root causes to the problem after they have drawn the sketch. In this case, the problem solver along with other participants used the “5-Whys” approach touted by Toyota. The intent for such brainstorming is to investigate deeply to ascertain the root causes. The major root causes that emerged from the brainstorming sessions were absence of appropriate therapy protocol for the therapists, and lack of clear job responsibilities of various caregivers and their interactions with others involved in the process.

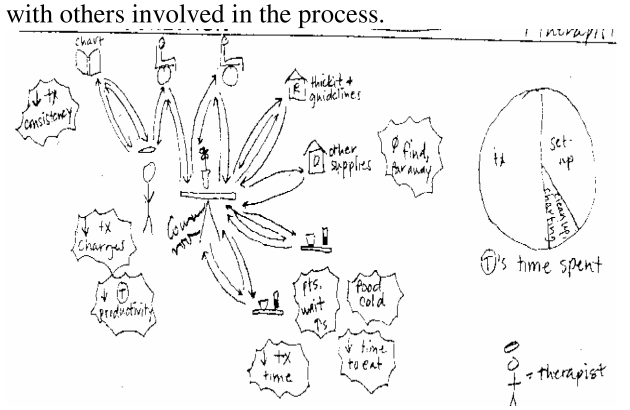

Figure 1: Current State of meal therapy

These two root causes, in essence, reflected poorly specified activities and connections in the process.

In order to address the root causes, the participants decided on certain countermeasures:

- the techs will deliver the patients to the common area prior to the therapy session;

- the therapist will use a treatment kit containing all necessary supplies and a goal page retrieved from a designated place;
- the techs will return the patients to their individual rooms and clean the table; and
- developing a policy/protocol for therapeutic meal program.

Having all the necessary information in the background, the problem solver with the aid of other participants hand sketched the envisioned target state on the right hand side of the A3 report (see figure 2). The fluffy clouds (the benefits) the participants contemplated from the efforts were consistent treatment levels, reduced charting time, hot food, increased treatment time, productivity, one designated location for all essential supplies, and a 'goal page'. The author drew the fluffy clouds alongside the target state diagram on the A3 report. Prior to developing the target state she discussed with all caregivers for their suggestions and ideas. That included nurses, techs, speech therapists, occupational therapists, a dietitian, a scheduler, and a secretary. She drew it from the input she received and asked others for their confirmation. The target state she drew conformed the three design rules of TPS regarding activities, connections, and pathways.

In the target state, the tech will bring the patient to the common area and prep them prior to therapy. The therapist will collect the schedule from the scheduler; retrieve the treatment kit containing all necessary materials (wash cloth, tape, thickener, and straws) and the guidelines (goal) from a designated cupboard located very close to the common area. S/he will collect the chart from a designated shelf. S/he will get the hot food trays just before the beginning of the therapy session. S/he will then perform the therapy as per the established guidelines in the chart. On completion of the therapy, s/he will inform the secretary who will page the techs to return the patients to their individual rooms and clean the room.

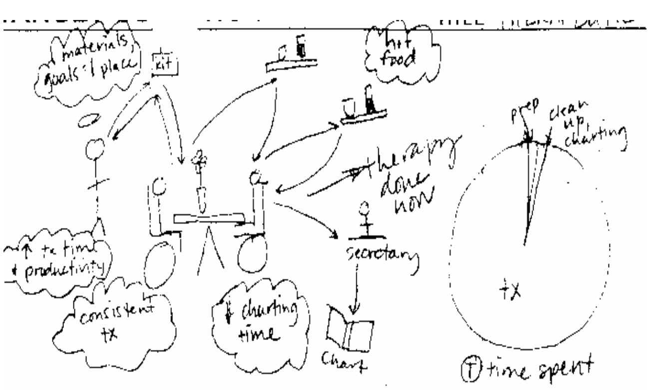

Figure 2: Target State of meal therapy

In order to achieve the target state, the team devised a comprehensive implementation plan (steps to realize the target state). The problem solver in consultation with others developed the goal page and a protocol for therapeutic meal program. The goal page contained specific goals (feeding, positioning, swallowing, cognition, and communication) to be achieved by a therapist during a therapy. The protocol, which came into effect from May 2004, outlined the responsibilities of each person (speech language therapist, occupational therapist, schedulers, RNs, CNAs, Dietitian, RNU secretary, RNU aide) and how they will connect with other caregivers in the process to make it more efficient. With the aid of techs she developed a tool kit containing all supplies and also presented the new protocol to all the other caregivers (therapists, nurses, certified nursing assistants, and secretary).

Results

The implementation of the action plans yielded an 80% improvement in billable time, consequently increased revenues, and also improved patient care. The set up time and the documentation time decreased from an initial 20-25 minutes to 5 minutes. The actual patient care time increased from 20-25 minutes to approximately 40 minutes.

Discussion

Initially the group meal therapy process was vaguely defined. If we trisect the total therapy process into three different segments: pre-therapy, therapy, post-therapy we notice none of the three segments had a well-defined process. As a result, there was unwanted communication, runarounds and confusion in the entire process from beginning until end.

During the pre-therapy session, as the supplies were not kept in a designated place, the therapist had to contact other caregivers (techs, RNs) - an ambiguous connection. In addition, nobody was responsible for arranging all critical supplies for the meal therapy process - an example of lack of specificity in activity (i.e., arranging all necessary medical supplies prior to therapy). Similarly, the therapist had to bring the patients to the common area for therapy as there wasn't any designated person to do that work. In other words, there was no clear connection between the requester of service (therapist) and the provider of service (tech), which resulted in undesirable connections.

While performing the therapy, the therapists had no idea about the goals to be met, as no guidelines existed before instituting the A3 process. So often they had to contact other therapists for the goals to be achieved. The therapy process thus varied from one therapist to another. Consequently, at times, the therapists did not meet the goals leading to poor patient care. This situation shows that an activity not properly specified (i.e., how to perform meal therapy) resulted in unnecessary connections and eventually poor patient care.

On a similar note, in the post-therapy session, who will return the patient to their respective room and how that service will be triggered were also initially vague. This could be construed as a poor connection, which caused confusion regarding sending back the patients to his/her individual room. It was later clarified as part of the A3 problem solving effort. So, the therapist, on completion of the therapy, will inform the secretary, who in turn will page the tech to return the patients back to his/her individual room.

The problem solving team used the TPS design Rule 1 (specifying activity) and Rule 2 (creating direct connection between adjacent supplier and customer) to develop the goal page and the RNU protocol for the entire process. The goal page delineated specific "goals" to be achieved by the therapists during therapy session. The protocol explicitly articulated the responsibilities of each caregiver in the process and how they would connect with others sequentially in successfully and efficiently carrying out the total meal therapy process (pre-therapy, therapy, and post-therapy).

The pathway for the process from beginning to the end prior to the A3 problem solving process was not describable as the process unfolded differently in every session. In fact, it was interrupted at every step in the process. By outlining the activities and the connections explicitly in the goal page and the protocol, the participants in the problem solving process simplified the pathway exceedingly. This seems to suggest that simplified activities and connections lead to simplified pathways. It, therefore, seems that defining activities and creating binary and direct connections add to superior operational performance.

An interesting point to note from the study is who initiated the study. It was a therapist, a front-line staff member, who knew the work the best and had a real stake in the outcome of the process. She and others undertook a very in-depth analysis of all aspects of the process, observed its deficiencies first hand, created an improved process, and supported it for sustenance. This is in stark contrast to the conventional problem solving by a middle or senior level executive in a non-TPS organization. In most cases, those efforts failed to fructify due to the lack of support from the front line staff, who were never allowed to participate in such efforts.

Another striking point of the study was the effort the initiator of the study made to interact with actors from other disciplines to make the improvement process succeed. She not only involved them in observing and collecting contextual data for the current state but also discussed with them their suggestions and ideas for devising the target state. Without such interaction, her efforts would have produced marginal improvement, at best.

Conclusions

This study suggests that the TPS design rules may be effective in improving work processes in health care. The study also buttresses the argument that specifying work for achieving superior results may be true for non-manufacturing sectors of the economy.

Our results provide evidence that specifying work is not only suitable for mechanistic organizations such as Toyota but also may be suitable for organic organizations such as health care. Our study in the hospitals reveals that many work processes were repetitive in nature and therefore using TPS design rules to improve processes made logical sense.

Continuous improvement is the order of the day and is an absolute necessity to survive. Given the fact that the costs in health care are increasing everyday; reimbursements from the payers are shrinking day-by-day; staff have little time for problem solving; it makes logical sense to adopt a less time consuming, low cost, pragmatic approach such as using TPS design rules to transform health care work processes to improve organizational performance. It not only prevents management from committing huge organizational resources but also helps develop the competencies of both staff and the organization to create new routines or change routines within their day-to-day activities to remain competitive. Moreover, by participating in the problem solving process, organizational members are able to make a transition from silo mentality to system thinking which is critical for effective process improvement in health care.

Obviously all these lead to a simple question. Where do we start? Experts (Spear and Schmidhofer, 2005) suggest selecting a small segment of a bigger system, studying it in-depth, improving it by specifying work as much as possible, and the improvement process would automatically start propagating in other relevant areas thus transforming it into a lean enterprise.

Acknowledgements

This study and the paper would not have been possible without the generous help of National Science Foundation who funded this project. The author is grateful to the interviewee who untiringly provided all relevant information for this paper, and an exceptionally helpful anonymous reviewer for editing the document.

References

Benedetto, A. R. 2003. Adopting manufacturing-based Six Sigma methodology to the service environment of a Radiology film library. *Journal of Healthcare Management*. 48 (4): 263-280.

Blumenthal, D., & Kilo, C.M. 1988. A report card on continuous quality improvement. *The Milbank Quarterly.* 76 (4): 625-648.

Biotech Week.. 2004. Spending growth to nearly double in the next decade. March 3: 116.

Cusumano, M. A. 1988. Manufacturing innovation: Lessons from the Japanese auto industry. *Sloan Management Review.* 30 (1): 29-39.

Industry Week.. 2003. Lean health care? It works! November: 34-40.

Jimmerson, C, Weber, D., & Sobek, D. K. 2005. Reducing waste and errors: Piloting Lean Principles at IHC, *Joint Commission Journal on Quality and Safety.* 31 (5): 249-257.

Krafcik, J. F. 1988. Triumph of the lean production system. *Sloan Management Review.* 30 (1): 41-51.

Ohno, T. 1988. *Toyota Production System: Beyond large scale production.* New York: Productivity Press.

Ovretveit, J. 1997. A comparison of hospital quality programmes: lessons for other services. *International Journal of Service Industry Management.* 8 (3): 220-235.

Revere, L., & Black, K. 2003. Integrating Six Sigma with Total Quality Management: A case example for measuring medication error. *Healthcare Financial Management*, 48 (6): 377-391.

Shingo, S. 1989. *A study of the Toyota Production System from an Industrial Engineering viewpoint*. Portland: Productivity Press.

Shortell, S. M., Bennett, C. L., & Byck, G. R. 1998. Assessing the impact of continuous improvement on clinical practice: What it will take to accelerate progress. *The Milbank Quarterly.* 76 (4): 593-623.

Sobek, D. K., & Jimmerson, C. 2003. *Applying the Toyota production system to a hospital pharmacy.* Paper presented at the Industrial Engineering Research Conference, Portland, Oregon.

Spear, S. J. 2005. Fixing healthcare from the inside, today. *Harvard Business Review.* 83 (9): 78-91.

Spear, S. J. 2004. Learning to lead at Toyota. *Harvard Business Review.* 82 (5): 78-86.

Spear, S., & Bowen, H. K. 1999. Decoding the DNA of the Toyota Production System. *Harvard Business Review.* 77 (5): 97-106.

Spear, S. J. & Schmidhofer, M. 2005. Ambiguity and workarounds as contributors to medical error. *Annals of Internal Medicine.* 142 (8): 627-631.

Thompson, D. N., Wolf, G. A., & Spear, S. J. 2003. Driving improvement in patient care. *JONA.* 33 (11): 585-595.

Torres, E. J., & Guo, K. L. 2004. Quality Improvement techniques to improve patient satisfaction. *International Journal of Health Care Quality Assurance.* 17 (6): 334-338.

Tucker, A. L. 2004. The impact of operational failures on hospital nurses and their patients. *Journal of Operations Management.* 22: 151-169.

Tucker, A. L, & Edmondson, A. C. 2003. Why hospitals don't learn from failures: Organizational and psychological dynamics that inhibit system change. *California Management Review.* 45 (2): 55-71.

Wall Street Journal. 9 November 2004.

Waldman, D. J, Kelly, F., Arora, S., & Smith, H. L. 2004. The shocking cost of turnover in health care. *Health Care Management Review.* 2004. 29 (1): 2-7.

Walley, P., & Gowland, B. 2004. Completing the circle: from PD to PDSA. *International Journal of Health Care Quality assurance.* 17 (6): 349-358.

Westphal, J. D., Gulati, R., & Shortell, S. M. 1997. Customization or conformity? An institutional and network perspective on the content and consequences of TQM adoption. *Administrative Science Quarterly.* 42: 366-394.

Zabada, C., Rivers, P. A., Munchus, G. 1998. Obstacles to the application of Total Quality Management in Health care Organizations. *Total Quality Management.* 9 (1): 57-66.

Biographical Sketch

Manimay Ghosh, is a Ph.D candidate in Mechanical and Industrial Engineering department at Montana State University, Bozeman, Montana. He is currently investigating the role of TPS in transforming health care. He has 17 years' experience in the area of manufacturing planning and industrial engineering.

Durward K Sobek, II, Ph.D is currently associate professor in Mechanical and Industrial Engineering department at Montana State University, Bozeman, Montana. He has published several articles in reputed journals in the area of lean product development and lean applications in health care.