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Reducing Waste and Errors: Piloting Lean Principles at Intermountain Healthcare

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When applying principles from the Toyota Production System (TPS), observers are repeatedly surprised to discover just how much waste exists in their day-to-day work—as much as 35%.[1] One reason is that *how* processes should ideally work is rarely specified clearly in health care operations, creating inconsistency in care, unreliable delivery systems, and constant caregiver interruptions—which in turn create inefficiencies, higher operating costs, increased potential for errors, and worker frustration.

The TPS, also called "lean manufacturing,"[2] represents a fresh way to look at work systems within health care. This system, based on fundamental industrial engineering principles and operational innovations, is used to achieve waste reduction and efficiency while simultaneously increasing product quality. Several key tools and principles, adapted from Toyota to health care at Community Medical Center (Missoula, Montana), with support from Montana State University (Bozeman, Montana), have proved effective in improving hospital operations.[3,4]

In October 2002 Intermountain Health Care (IHC; Salt Lake City) initiated a pilot project to test Toyota's methods for continuous improvement. This article describes the TPS tools and principles that have particular relevance to health care.

Article-at-a-Glance

Background: The Toyota Production System (TPS), based on industrial engineering principles and operational innovations, is used to achieve waste reduction and efficiency while increasing product quality. Several key tools and principles, adapted to health care, have proved effective in improving hospital operations.

Tools: Value Stream Maps (VSMs), which represent the key people, material, and information flows required to deliver a product or service, distinguish between value-adding and non–value-adding steps. The one-page Problem-Solving A3 Report guides staff through a rigorous and systematic problem-solving process.

Pilot Project at Intermountain Healthcare: In a pilot project, participants made many improvements, ranging from simple changes implemented immediately (for example, heart monitor paper not available when a patient presented with a dysrythmia) to larger projects involving patient or information flow issues across multiple departments. Most of the improvements required little or no investment and reduced significant amounts of wasted time for front-line workers. In one unit, turnaround time for pathologist reports from an anatomical pathology lab was reduced from five to two days.

Conclusions: TPS principles and tools are applicable to an endless variety of processes and work settings in health care and can be used to address critical challenges such as medical errors, escalating costs, and staffing shortages.

Why Learn from Toyota?

In the 1980s, the automotive industry in the United States was losing market share to foreign competitors, particularly Japanese automakers, who could manufacture cost-competitive automobiles with fewer defects and higher customer satisfaction.[2] When researchers traveled to Japan to discover the secret of their success,[2] they found an entirely different system of production—which they called "lean manufacturing" (because higher-quality output was obtained at half the cost in half the time of traditional manufacturing methods). During the last 10–15 years, companies using these lean manufacturing practices report productivity improvements in the triple digits, defect rates falling by orders of magnitude, significantly shortened order-to-delivery times, increased customer satisfaction, and greatly reduced employee turnover.[5,6] The concepts are revolutionizing manufacturing in the United States.

Lean manufacturing is often described as a Japanese phenomenon, but the system was invented by one company—Toyota Motor Company.[7] As Toyota perfected its system and began making huge strides domestically, other Japanese manufacturers took note and copied its system.[8] What American researchers saw and reported as a Japanese method was actually just Japanese manufacturers copying Toyota more quickly than did American companies.

Toyota's production system has enabled the company to become the recognized industry leader in product quality and profitability. In 2002 the company cut $2.6 billion out of its $113 billion in manufacturing costs without any plant closures or a single layoff and targeted another $2 billion in 2003.[9] We believe that health care can learn a great deal about understanding and improving work processes from this best-in-class company, which has recently become the No. 2 automaker in global sales.[10]

TPS Principles

Some describe lean manufacturing as a philosophy, a perspective that abhors waste in any form and strives to eliminate defects—and continually attacks both in a never-ending pursuit of perfection.[11–13] Presumably because such platitudes provide little practical guidance, most descriptions of lean manufacturing provide an interrelated set of practices that range from overall material flow in the factory to detailed work and equipment design to human resource practices.[13–15] The difficulty, though, is that the tools and practices are finely tuned to a specific environment—that of high-volume, low-variety production of durable goods. It seems unlikely that the specific practices could transfer to another environment with equal success. In fact, one can find few (if any) documented cases of lean implementation not closely tied to manufacturing.

Table 1. The Notion of "Ideal," as Adapted for Health Care

- 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, and professionally

For Spear and Bowen,[16] the "essence" of the Toyota system can be found in a set of principles that guide process improvement at Toyota. The TPS principles, as now described, are consistent with previous work on Toyota's vehicle design system.[17]

As a first principle, Toyota relentlessly pursues an ideal state of error-free work.[16] Every change must move the organization closer to this ideal along one or more dimensions; otherwise, the change is not approved. Toyota's notion of "ideal" fits health care so well we adapted it, as shown in Table 1 (above).

A second principle is problem solving that happens as close to the event as possible, in time and person, supported by a coach. Problems are quickly identified because clear specification of the work and clear definitions of "defect-free" outcomes makes it readily apparent when defect free does *not* occur (that is, they do not conform to the ideal). Line workers are considered experts at doing the work *and* at redesigning work, in the recognition that employees are assets rather than expense items.

Third, vigilant consideration of the current work systems and evaluation of the ability to produce defect-free drive a production system that changes as soon as a better way is known. Proposed changes are called "countermeasures" (not one-time "solutions" or temporary "quick fixes") and are implemented as scientific experiments. Hypotheses about expected performance are made explicit, and actual results are then measured and compared to predicted results.[18]

Fourth, process redesigns focus on specifying work activities, making clear connections between those requesting and those receiving goods and services and simplifying the production pathways of goods and services.[16] Processes improve and problems become more transparent when activities are specified according to content, sequence, timing, and outcome so that regardless of who performs the work, it is completed in the best-known way with defect-free results. Processes improve when connections between workers making requests and providing services are direct, simple, and binary—doing so makes them prompt, efficient, and reliable. In addition, processes improve when goods and services follow the same, simple pathway through the system every time without interruption. These simple rules not only define the ideal work process but enable workers to quickly see opportunities to improve.

Pilot Project at Community Medical Center

Given the challenges of health care—increasing costs, complex regulatory environments, increasing error rates, labor shortages in key sectors, and the aging baby boomer population—in 2001 two of the authors [C.J., D.K.S.] collaborated on a pilot project at Community Medical Center (Missoula, Montana) to determine whether and how the principles of TPS might apply to health care.

We began by adapting two tools Toyota uses in redesigning work and problem-solving and applying them to hospital operations. The tools embody the TPS principles and provide a mechanism to reinforce the principles while facilitating problem-solving activities. The effort has brought about significant, medium-scale improvements across many areas of the hospital, including a cardiology diagnostic lab, pharmacy, rehabilitation, patient billing, and facility services.

Value Stream Map (VSM)

VSMs represent the key people, material, and information flows required to deliver a product or service. They are designed to distinguish value-adding versus non-value-adding steps. In manufacturing, value-added time is when the part is processed or assembled, and non–value-added time is time spent in inventory. In health care, a value-adding step would be a nurse's interview to obtain important information from the patient, whereas a non–value-adding step would be a patient waiting for a physician to arrive at the examination room.

Rother and Shook[19] provide a hands-on description of a VSM. Simple diagrams depict the process steps (boxes), the material flow between steps (fat arrows), and information flows indicating work orders/schedules (thin arrows). Key data on the time each step takes and on the time between steps provide a simple means to analyze the overall process or pathway. The manufacturing VSM is easily adapted to most health care operations and enables the team to document and understand the steps in the request for a product or service and the steps (and delays between those steps) necessary to answer that request. It is used for the following purposes:

- To understand the high-level view of a process and recognize where specific problem solving can be focused to improve the process
- As a springboard for creating a "future state map" that outlines a clear goal toward which the team applies its improvement efforts

The Problem-Solving A3 Report

The Problem-Solving A3 Report fits on one side of an 11" × 17"-sheet of paper (roughly equivalent to the A3-size paper [metric units]; hence the name). We adapted Toyota's more advanced A3 reporting system to health care, creating a template that has been used in dozens of hospital operations problems (Figure 1, page 252, and Sobek and Jimmerson[4]).

The A3 report addresses a specific problem in a systematic fashion as follows:

1. The issue or problem is stated through the eyes of the customer (for example, "patient care is delayed waiting for stat lab results" instead of "the lab doesn't get the results to the ED on time").

2. The current work procedures are represented graphically as the "current condition," based on *direct observation of the problem*. The graphical representation enhances the writer's own understanding of the problem while facilitating communication with others. The diagram must be based on what actually occurs day-to-day, rather than recollections, generalizations, or descriptions of what "should" be happening, so direct observation is the preferred data collection method.

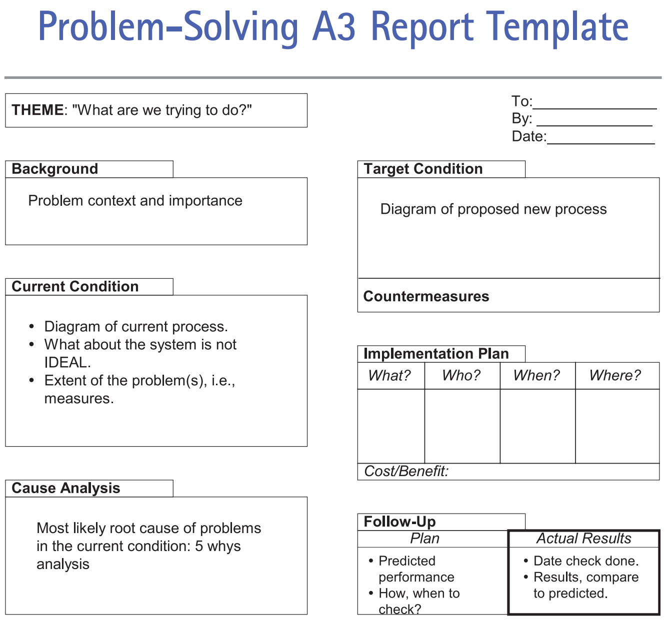

Figure 1. *The A3 report guides the problem solver through a rigorous and systematic problem-solving process.*

3. Specific problems are identified and quantified, and the root causes are investigated through a deep understanding of the current work processes. The most common approach is the 5 Whys method (asking "why?" five times in series to get to the root of the problem).

4. A better way to work is proposed through a graphical representation of the "target condition" that moves the work closer to the ideal. The target condition is achieved through a set of countermeasures designed to alleviate the root causes identified.

5. An implementation plan identifies the steps to make the changes happen and assigns responsibility to individuals with a deadline for completion.

6. A follow-up plan predicts the improvement expected as a result of implementation as specifically as possible and indicates when and how to measure the success of the implementation. Space is left to record the actual results and compare with predicted results.

The A3 report provides a rigorous and systematic problem-solving process. The simple, one-page format requires that problems be taken in small, doable chunks so that workers can identify and make improvements rapidly. We have discovered that coaching is often critical to effective, real-time problem-solving. The coach does the following to ensure compliance with the A3 problem-solving process:

- Insists on direct observation to construct the current condition diagram
- Guides on how to construct a diagram that is both accurate and depicts the problem source
- Makes sure that the root cause has gone deep enough
- Requires that all parties affected by the change have been consulted and are supportive
- Cross-checks to make sure the target condition moves the organization closer to ideal and conforms to the guidelines regarding activities, connections, and pathways
- Most importantly, makes certain that implementation and follow-up actually happen and get documented

We have discovered that at the root of every operational problem we have studied is a poorly specified activity, a vague unreliable connection, or a complex pathway. Although it is not proof positive, we have not yet encountered an example where activity specification, connections, or pathways were not central to the problem.

Training Course

To facilitate widespread use of the tools and application of the principles at Community Medical Center, a seven-week training course and workbook[20] was developed. In each two-hour session, participants learn new material on the tools and principles and then complete an assignment in their home departments before the next session. By the end, each participant has completed a VSM and A3 report on an actual workplace problem. The outline for the training course is as follows:

- Week 1. Introduction to Toyota and TPS principles; direct observation
- Week 2. Value Stream Mapping: Flow
- Week 3. Value Stream Mapping: Data
- Week 4. A3 problem solving: Current condition and root cause
- Week 5. A3 problem solving: Target condition and implementation plan
- Week 6. A3 problem solving: Consensus-building; follow-up plan
- Week 7. A3 problem solving: Report final results

At the end of seven weeks, each participant has enough foundation to initiate problem-solving, and most participants can successfully complete a VSM or A3 report with reasonably low coaching time. At Community Medical Center, more than 150 people have taken this course (versus close to 300 at IHC at the end of the first year).

Pilot Project at IHC

In 2002 the medical director of the medical-surgical intensive care unit (ICU) and the nurse manager of the respiratory ICU initiated a pilot project at IHC to apply TPS locally. They had already developed a culture of front-line empowerment in the shock trauma ICU through pioneering work in protocol development and quality improvement. The TPS tools and principles were introduced through the training course developed at Community Medical Center, but several adjustments were made in transferring the course to the new environment. First, to ensure sufficient coaching support, participants met with the trainer [C.J.] one-on-one between sessions. Second, rather than allow participants to register for the training course on an ad hoc basis, 16 participants per course offering were carefully selected in areas of related units. The initial 10-week session (3 additional weeks were used to continue on-site work with the participants and train coaches and instructors who co-taught the next course) focused on 4 intensive medicine units: the shock/trauma ICU, a medical ICU, a general medical/surgical unit, and the emergency department. We included a minimum of four people from each unit, including the manager and at least two frontline staff. We attempted to include at least one person on each unit with time out of direct patient care who could become on-the-unit coaches. This allowed the staff to continue their work while the coach initiated the observation and problem analysis necessary to redesign problematic work. A third change was to be more proactive in soliciting physician involvement.

From October 2002 to December 2003 a total of 90 clinical staff, managers, physicians, and management engineers and 48 members of the corporate information technology department had finished the training in nine course offerings. Staff from laboratory, dietary support services, and pharmacy staff also became involved, broadening the scope well beyond the initial four units.

Results

The preliminary results to date at IHC are promising. Course participants addressed real-work issues and made many improvements that ranged from simple changes implemented immediately (for example, heart monitor paper not available when a patient presented with a dysrythmia), to larger projects involving patient or information flow issues across multiple departments. Initial improvement efforts were completed during the seven-week classes, while some continued beyond the end of the course. Table 2 (page 254) lists a few representative examples of process improvements.

Most of the improvements required little or no investment to implement and reduced significant amounts of wasted time for front-line workers. The improvements that did require a purchase were justified by the salaries of worker time saved. Reduction of overtime hours resulted in real dollar savings immediately, whereas reductions in wasted staff time not affecting overtime realized immediate gains in error reduction and employee, patient, and physician satisfaction. Eventually, all reductions in waste can be expected to add to the bottom line. A 10% reduction in waste can be expected to increase operating margin by 2.5%.[1]

Case Study

To illustrate application of the TPS principles, we describe a case study in the anatomical pathology lab in which the goal was to reduce the turnaround time of pathologist reports. Anatomical pathologists' reports often took up to five days to reach the treating physician. Previous attempts to improve turnaround time yielded no improvement and sometimes made things worse. In addition, specimen volume increased by 40% because of marketing efforts and centralization efforts at IHC, straining capacity and compounding the problem.

A team composed of technicians and pathologists—the people closest to the work—was assembled to address the problem. The team developed a VSM of the entire workflow, from receiving the specimens to delivering the pathology report to the referring physicians, by direct observation. The VSM showed that several areas

Table 2. Examples of Process Improvements at Intermountain Healthcare*

Problem Identified	Improvement Made	Savings/Benefit
New medication orders written during rounds arrived late (sometimes as much as 4 hours).	Enter new medication orders during rounds with a wireless laptop	■ Reduced time to treatment from 4 hours to 12 minutes ■ Reduced IV backlog in pharmacy ■ Reduced number of steps in getting order to pharmacy
Nurses sharing one glucometer on an ICU where most patients were on an intensive insulin protocol. Resulted in delays, interruptions, some unlabeled specimens.	Install glucometers in each room in ICU	■ Reduce time to do glucose check from 17 to 4 minutes. ■ Improve ability to consistently implement the protocol. ■ No unlabeled specimens at risk of erroneous identification ■ Fewer RN interruptions and frustration
Unit clerk interrupted while taking off new MD orders.	Create quiet area for taking off MD orders during busiest hours	■ Decrease in treatment delays (from average 43 minutes to 10 minutes)
New orders frequently missed and documentation incomplete in the ED due to misplaced charts.	Improve chart flow process with clear signals for each station	■ Improvement in completed chart rate (60% increase in completed charts) ■ Decreased time and frustration looking for charts ■ Improved accuracy and time to billing
Paper checks being processed/mailed each week. This work had been languishing for several months	Implement electronic payment for large vendor accounts	■ Save $849,000/year by negotiating discount for electronic payment with one large vendor ■ Save $125,000/year postage

* ICU, intensive care unit.

of delay, inconsistent work processes, and labeling errors seem to be occurring in the grossing room (where initial processing and documentation of tissue samples takes place) and created most of the delay in turnaround time. A goal of a two-day turnaround was established.

The team then used the A3 problem-solving approach to study particular problem areas highlighted in the VSM. The current condition diagram developed from observation of the current workflow is depicted in Figure 2 (page 255).

The diagram revealed a complex flow (or pathway) with numerous opportunities for significant delays. The root cause analysis identified four specific problems, which were addressed with the following specific countermeasures:

- The flow of paperwork through the process did not align with the flow of the specimens, causing three to four hours per day of waste as transcriptionists manually matched paperwork to specimens. The countermeasure involved a relatively simple software fix that cued and printed the paperwork in the same order as the specimen flow.
- Two scheduling incongruities created interruptions to the flow. For one, the grossing room operated from 7:00 A.M. to 6:00 P.M., but many specimens were delivered at 6:00 P.M. and were not processed until the next day. Also, histology embedding did not begin until 5:00 A.M., so slides could not get to the pathologists until 10:00 A.M. at the earliest. As a countermeasure, the grossing room expanded operations to 10:00 P.M., enabling an additional run per day, and histology embedding started up at 3:00 A.M. The technicians who do the work made these decisions once they realized the improvements that would result, eliminating the need for physical capacity expansion.
- Transcription reports to the pathologists previously had a four- to five-hour turnaround, directly contributing to the delay in the final reports. The transcriptionists were moved out of the work area to eliminate interruptions and clutter, reducing the turnaround of reports to one hour.

Current State Diagram for Pathology Specimens–Grossing Room

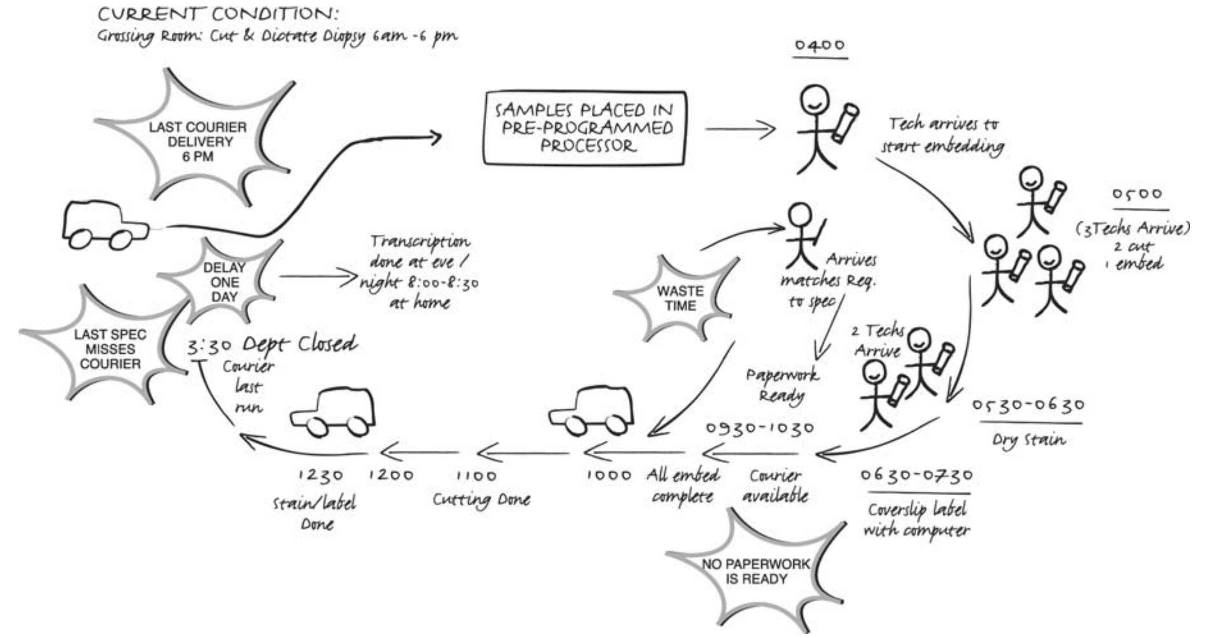

Figure 2. *The current state diagram revealed a complex flow (or pathway) with numerous opportunities for significant delays. When specimans enter the lab, they are attached to the requisition (req.), which contains patient information from the referring physician, as well as the reason for requesting the biopsy. Through the processing stages the speciman (spec.) and requisition are separated and must be matched up again.*

- Work processes throughout were inconsistent, leading to labeling errors and further delay. The countermeasure was to clearly specify the steps in the process in accordance with the design principle above. Labeling errors decreased from an average of 3 per month for the previous 12 months to one error in the first 2½ months of the new process, improving throughput.

Although this particular problem had been tackled numerous times without any success, following the TPS principles and the rigorous problem-solving tools enabled the two-day turnaround goal to be achieved in two months. People close to the work studied the problem using direct observation. They used diagrams to develop a shared understanding of the system as a whole and to communicate improvement ideas. They addressed root causes of problem symptoms by applying simple rules for process design. At every step, the people who do the work were involved in making the improvements. For the first time, they were able to understand their role in the overall workflow and the impact of their work on the outcome. Figure 3 (page 256) shows the target condition for the revamped grossing room flow, which will now become the new current state for the next round of improvements.

Discussion

Three key factors seem to contribute to the success of TPS implementation. First, participants learned to look at their work with a fresh view and to see waste in daily work activities. After working with unnecessarily complicated systems fraught with workarounds and rework, staff for the first time began to see the waste they lived with every day and had previously assumed was part of their job. They also put a dollar value on their wasted time and began to realize the fiscal significance of addressing small problems.

A second success factor was the front-line staff's enthusiasm for making improvements. Because work redesign is done as close in time and person as possible, the real-time involvement of staff who identify problems, and their input into the current condition and ideas for a better way to work, motivated the staff beyond our initial anticipation. Employees tend to resist imposed change. However, we found that most employees are eager to make change that

Future State Diagram for Pathology Specimens–Grossing Room

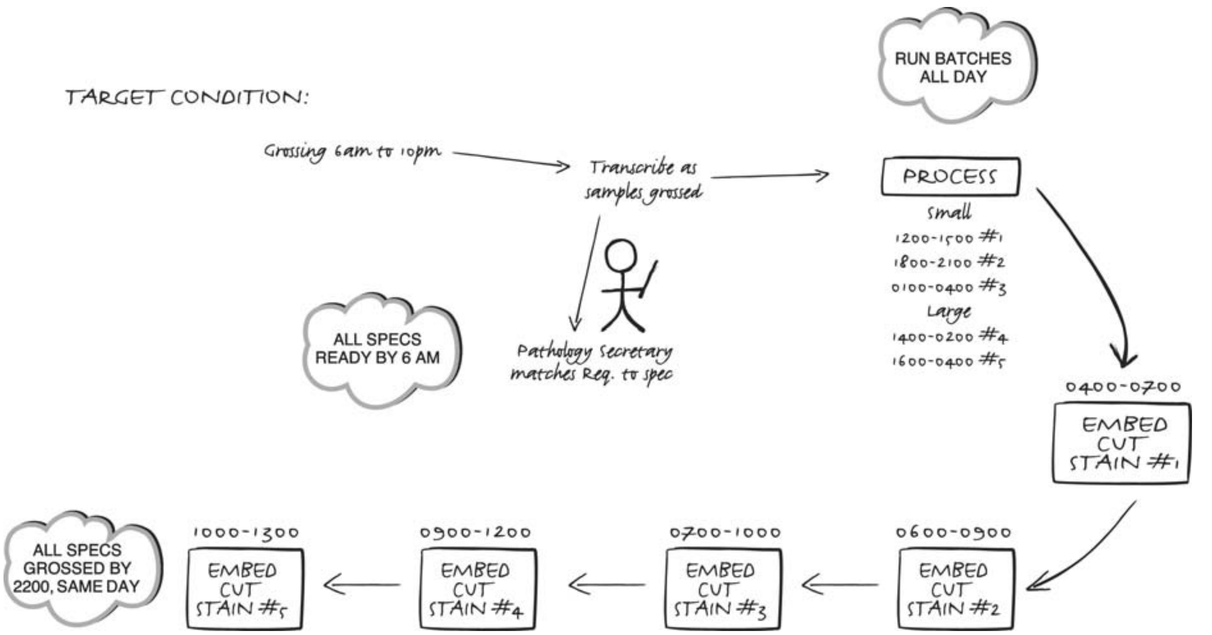

Figure 3. *The target condition for the revamped grossing room flow will now become the new current state for the next round of improvements.*

will improve their own work and efficiency when they are part of a redesign process that is consistent and reliable.

Third, use of a common template such as the A3 problem-solving method facilitates clear, succinct, and objective communication about interdepartmental issues. Several polarizing issues became neutralized as staff focused on what was right for patients and customers. For example, when an ICU identified the need to change the way enteral feeding formula was delivered to the units, dietary and central distribution initially resisted but were won over when informed of the problems that patients were experiencing. When pharmacy staff identified a software problem that caused five days of wasted work for the billing technician, information technology did not consider it a priority until direct observation of the work process demonstrated the problem and its consequences.

Participants reported that use of the tools also accelerated issues already in process (but languishing in lengthy, time-consuming meetings) and facilitated communication and buy-in across departments.

On the basis of this initial experience, it appears that different hospital units may require different approaches to implementation. The laboratory, pharmacy, and information technology had the easiest time making change, engaging staff who had not yet taken a class and eliminating waste. Staff in these departments were already process-focused and were better able to allocate time to process improvement than were staff in the direct patient care areas. Nursing units, in contrast, experienced greater difficulty working without a dedicated resource (a coach) to respond to problems that arise and to coordinate the problem resolution. Clinical educators functioned on our trial units as coaches—and they seemed to be a natural fit for the coaching role—but they struggled to add the new activities to a full workload.

Finally, senior leadership plays a critical role. Many of the inefficient processes we identified were actually created by high-level decisions made without a good understanding of the impact on work processes and use of staff time. Ideally, senior leaders would know and understand this problem-solving method and give units the responsibility and resources to self-manage toward ideal. Although we started at IHC with a bottom-up strategy to demonstrate effectiveness in small areas at the front line, the drive from the top helped ensure workers that this was not another "flavor-of-the month" effort. Growing involvement of leadership (administrative and physician) is key for securing sustainability and success.

Conclusions and Next Steps

TPS principles and tools are applicable to an endless variety of processes and work settings in health care and can be used to address critical challenges such as medical errors, escalating costs, and staffing shortages.

To promote TPS throughout IHC, we are following a Toyota principle of creating "pull"—interest created based on reports by those using the approach. As managers learn the principles and tools and see results, they are challenged to fully deploy TPS on their units. Although the work so far has been done without any additional resource, a key next step is to fully implement TPS in one department for a sustained period of time, with a minimum of a dedicated ½-FTE for coaching. We are in the process of examining several units for this purpose. In the first unit, a large hospital pharmacy, implementation of TPS was just getting underway in January 2005. In addition, a laboratory department has developed the infrastructure and support to involve all staff in problem solving. Numerous units have requested support for unit-based deployment, but this is beyond existing resources.

IHC's experience with TPS, which began as a two-year grassroots effort, has been incorporated into systemwide leadership development training. We hope that continued adoption and application of the tools will lead to TPS becoming a standard way of solving problems, with all staff skilled at identifying waste and making improvements. Additional cultural changes will need to include greater leadership focus on work processes and increased support for front-line staff to make improvements. J

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