A Collaborative Approach to Lean Laboratory Workstation Design Reduces Wasted Technologist Travel

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Abstract

Lean methodologies have been applied in many industries to reduce waste. We applied Lean techniques to redesign laboratory workstations with the aim of reducing the number of times employees must leave their workstations to complete their tasks. At baseline in 68 workflows (aggregates or sequence of process steps) studied, 251 (38%) of 664 tasks required workers to walk away from their workstations. After analysis and redesign, only 59 (9%) of the 664 tasks required technologists to leave their workstations to complete these tasks. On average, 3.4 travel events were removed for each workstation. Time studies in a single laboratory section demonstrated that workers spend 8 to 70 seconds in travel each time they step away from the workstation. The redesigned workstations will allow employees to spend less time travelling around the laboratory. Additional benefits include employee training in waste identification, improved overall laboratory layout, and identification of other process improvement opportunities in our laboratory.

Lean is a quality and process improvement method that emphasizes consideration of the customer’s needs, employee involvement, and continuous improvement.1 Central to the Lean method is the identification and elimination of waste in all its forms. In this context waste is defined as elements of a process that either interfere with people doing their work effectively or do not provide value for the customer.2 Another important aspect of Lean is respect for the individuals performing the work. Lean tools have been applied across manufacturing industries and various healthcare settings to improve efficiency, productivity, and service.1,2 Several laboratories have documented improvements in report turnaround times, specimen flow, technologist productivity, quality, and other performance measures using these methods.3-8

A major challenge facing clinical laboratories is the shortage of laboratory workers. In 2009, 63% of surveyed laboratories reported difficulties in hiring medical technologists, motivating various laboratory groups to make plans for mitigating this shortage in the future.9,10 This shortage, combined with current economic pressures, has created a heightened need to critically reevaluate our laboratories to use technologists’ time efficiently and ensure these individuals’ engagement in the complex tasks they are trained to complete.

An additional challenge facing laboratorians is the rapid pace of change in diagnostic testing. New testing platforms and expansion of current platforms require periodic reevaluation of optimum workflow and workstation layout. However, large-scale redesign is not always possible because of cost, space, and time constraints. Therefore, laboratories often make changes and additions in a piecemeal fashion, adapting to the current configuration and adding equipment wherever possible without consideration of overall workflow.
or potential efficiencies. It is in this context that workflow improvement activities are often set.3,4

The planned construction of a new building to support an anticipated growth in our reference laboratory testing provided our department with an ideal opportunity. We reevaluated our current workstation layouts with the aim of reducing wasted travel by bringing the tasks closer to the technologists. We involved 67 laboratory employees and used Lean tools to evaluate and design more efficient laboratory workstations for use in our new building.

Materials and Methods

Event Preparation

The target statement and scope were defined before the event. The target statement was to “utilize standard work methodology to evaluate and redesign each laboratory area moving to the new laboratory building.” The scope of the event included manual and automated process steps comprising all 68 workflows for 4 clinical pathology laboratories moving to a new building: microbiology, molecular pathology, special chemistry, and immunopathology. For this study, a workflow was defined as an aggregate or sequence of processes or steps required to perform a test or a group of tests. Not included in the scope of this project were administrative, secretarial, and specimen accessioning functions. Specimen accessioning was excluded because a different set of tools (including process mapping and an analysis termed suppliers, inputs, process, outputs, customers [SIPOC]) to improve this area were planned for a later date. The improvement approach was that of kaizen. Kaizen means improvement or good change, and the term is commonly used to refer to well-defined tightly focused improvement efforts, usually occurring over a set number of days. Most kaizen events range from a few days to 1 to 2 weeks in duration; in our initiative, a series of 2-day kaizen events was held. Throughout the kaizen events, all issues raised by participants that were beyond the scope of this event were captured in a “parking lot” for future consideration. All activities were facilitated by 2 internal process engineers with experience in applying Lean methods to the manufacturing industry. The designated executive sponsors were the chair of the Pathology and Laboratory Medicine Institute and the head of the reference laboratory. Laboratory administrators were present when reports were made, but did not otherwise participate in the kaizen events.

Sixty-seven representative laboratory employees including technologists (61), technicians (4), and assistants (2) from the aforementioned laboratory areas were invited to participate in 1 or more of nine 2-day kaizen events. All participants underwent 1 hour of Lean overview training before the 2-day kaizen events. This training consisted of a lecture using slides (PowerPoint, Microsoft, Redmond, WA) covering the following Lean concepts: (1) 4 elements of the Toyota Production System (standards, connections, pathways, and improvement),11 (2) Lean tools, (3) plan-do-check-act, and (4) kaizen.

Temotoka

Each 2-day kaizen event began with review of the target statement and project scope. Participants then underwent temotoka or “close at hand” training. Temotoka focuses on improving efficiency by reducing the distance between the worker and items required to complete the work. The temotoka training included an interactive exercise during which participants were asked to evaluate the time required to reach items within the “optimal work window” vs outside this window. The term optimal work window refers to the ideal space or timeframe in which the work is most effectively or efficiently performed. In the laboratory, an optimal work window of 5 feet ensures that most of the work can be performed at 1 bench with limited travel required. For this event, we defined the optimal work window as a 5-foot-radius circle surrounding the working technologist. For this event we defined the optimal work window as a 5-foot-radius circle surrounding the laboratory technologist. The X at the center represents the laboratory technologist.

Waste

After completing the temotoka training and exercise, participants learned about 8 forms of waste and how to identify each form. Waste refers to any time, activity, or material that does not add value for the customer (the patient). These 8 forms of waste are detailed in Table 1. Each participant noted the 8 forms of waste on his or her clipboard. The participants were grouped into teams and then performed “waste walks.” For the waste walks, each member walked through his or her own laboratory area noting any instance of waste identified. Then each team gathered to report on and make an aggregate of wastes of any type observed. Each team then reported the waste walk findings to the larger group.

Figure 1 For this event we defined the optimal work window as a 5-foot-radius circle surrounding the laboratory technologist. The X at the center represents the laboratory technologist.
On day 1, the participants completed a standard work training module. This is a standard 1-hour module used across our organization to teach concepts including takt time, cycle time, work content and sequence, time observation, standard work chart, standard work combination table, and spaghetti diagram. On completion of standard work training, each team created a current state spaghetti diagram to document all travel occurring within and outside each workstation during a routine workday. For this event, workstation was defined as the arrangement of work surfaces and equipment around the worker that comprises the space in which he or she performs work. The participants also outlined all major current work steps in order of occurrence. A current state standard work chart including the spaghetti diagram and work steps was created for each workflow. To evaluate wasted travel we calculated the number of times the technologist left the optimal work window during a routine workday.

New Workstation Design

The teams reviewed the current state spaghetti diagrams and completed 1 or more future state spaghetti diagrams to eliminate as many process steps occurring outside the optimal work window as possible. The teams were then given blue masking tape, tape measures, and adequate floor space to create life-sized workstation layouts. Team members practiced the outlined process steps in these model workstations. Through repeated cycles of design, testing, and modification, they developed the ideal workstation layout with designated locations for all items required to perform their tasks. For approximately 2 hours each team portrayed the final optimized design and major work steps in new standard work charts. Also noted were any items (such as centrifuges, sinks, refrigerators, and others) that would be ideally located in close proximity or adjacent to that workstation in the new laboratory building. The standard work charts, including the future state spaghetti diagrams and all noted suggestions for improved adjacencies, became the major source of input for the schematic design, detailed design, and construction design for the new building and were frequently referenced throughout the design process.

Analysis

We assessed current and future state workstation efficiency by calculating the number of process steps occurring outside the optimal work window as a percentage of total process steps for all 68 workflows analyzed. We considered any step moved from outside to within the optimal work window to represent elimination of waste (reduction of wasted travel occurrence). We also analyzed which work areas had the greatest proportion of process steps occurring outside the optimal work window in the current configuration.

To more fully understand the effect of work process steps located outside the optimal work window, we randomly selected 1 laboratory (immunopathology) for more detailed current state analyses. We assessed all process steps currently performed at this laboratory to determine distance traveled (measured in increments of ≤5 (optimal work window), 5-25, ...
25-50, 50-75, and >75 feet from the technologist) and determined the frequency and cycle time for each process step through time studies and manual counts.

**Results**

Sixty-seven laboratory employees, including representatives from 4 clinical pathology laboratory sections (20 from immunopathology, 27 from microbiology, 5 from molecular pathology, and 15 from special chemistry) participated in at least 1 of nine 2-day kaizen events. Of these 67 participants 55 were active front-line laboratory medical technologists and 12 were laboratory coordinators or managers. Sixty-eight workflows were included and spanned the immunopathology (21 workflows), microbiology (19 workflows), molecular pathology (14 workflows), and special chemistry (14 workflows) laboratories. Example workflows included vitamin D testing (immunopathology), media preparation (microbiology), fluorescence in situ hybridization staining (molecular pathology), and trace metals analysis (special chemistry).
Current State Analysis

Standard work charts were created for all 68 workflows analyzed. A total of 664 current work steps were documented in order of occurrence in standard work charts. The average number of current process steps per workflow was 13.5 (range, 6-59; standard deviation, 9.4). In the current configuration, 251 (38%) of the 664 steps required technologists to travel outside the optimal work window. The number of process steps occurring outside the optimal work area for each work area ranged from 2 to 27 (mean, 5.1; standard deviation, 3.7). The 5 workflows with the highest proportion of steps occurring outside the optimal work window were located in Immunopathology (2), Microbiology (1), and Special Chemistry (2). For these areas, 60% to 86% of work process steps occurred outside the optimal work window in the current state.

The workflow with the greatest proportion of steps outside the optimal work window was further analyzed and included for illustration Table 3. In the current vitamin D testing workflow, 6 of 7 work steps required the technologist to travel outside the optimal work window. Review of this workflow indicated that the only work step performed within the optimal work window was the analytical testing. Tasks that commonly required travel outside the optimal work window for the other workflows assessed are detailed in Table 4.

Future State Analysis

For the 68 workflows analyzed, the total number of process steps did not change from the current to the future state.
optimal work window in the future state was 1.2 per work area (range, 0-9; standard deviation, 1.5). An average of 3.4 steps moved from outside to within the optimal work window for each work area (range, 0-18; standard deviation, 2.8).

We further studied 1 laboratory (immunopathology) to determine the frequency and cycle of all work steps located outside the optimal work window. The frequency and cycle times for work steps occurring less than or equal to 5 (optimal work window), 5 to 25, 25 to 50, 50 to 75, and more than 75 feet from the technologist are presented in Figure 2. Based on these cycle times and frequency data, a technologist working in this area spends 8 to 70 seconds traveling round trip to locations more than 5 to more than 75 feet from the center of the optimal work window.

Other Findings

An additional benefit was that we were able to improve adjacencies between associated workstations and shared instruments or equipment in the final laboratory design. This occurred as participants noted their preferred work area locations, including desired adjacencies (items or areas they should be located near or adjacent to) during completion of their standard work charts. All adjacency requests were considered in the overall building floor plan.

The 2 most common “parking lot” items generated during the kaizen events related to inventory management and specimen movement. In 9 instances, participants documented a desire to improve the supply chain inventory management system. This item led to a subsequent kaizen event focused on improving the inventory management system to reduce unnecessary touch points and technologist time used to assess and order inventory and retrieve supplies. In 6 instances, participants identified a desire to improve specimen movement between various work areas. Specimen movement between laboratory sections was not in the scope of this project, but additional work focusing on specimen movement was planned for a subsequent improvement initiative. This work is ongoing.

Verbal feedback from the technologists on the process was obtained in the months following the event through personal interviews, capturing of report content, and participation in a subsequent continuing education event. The feedback was universally positive. Quotes from front-line medical technologists included:

“Actually seeing how many walking steps are wasted in the current lab setup and then being able to solve this problem through new lab design was an eye opener.”

“I was surprised at how much excess travel the employees were taking as they performed their daily tasks.”

“The new laboratory embodies travel reduction in our current process and is designed with adaptability for future process modifications and additions. This was possible through direct bench tech input in the early design phase…."

Discussion

We engaged 67 laboratory technologists in a collaborative redesign, using Lean methods, of the current laboratory workspace configuration. The participants developed current state standard work charts with spaghetti diagrams to identify work steps that required them to travel outside the optimal work window. Future state standard work charts were then created through an iterative process during which participants created, tested, and revised models of proposed workstation layouts. A total of 192 wasted travel events were eliminated in 68 workflows through this initiative. The output was used to design more efficient workstation layouts for a new laboratory building. The new workstations were considered more efficient because the work tasks could be completed within the “optimal work window” rather than requiring the worker to travel to another area.

Lean methodologies have been used in laboratories and other healthcare settings to aid identification and elimination of wastes. These tools can be applied to either reconfigure existing laboratory space or design new spaces. We enjoyed a rare opportunity to design a completely new laboratory workspace, and in doing so, faced the challenge of designing the most efficient workspace possible. While the aim of this initiative was to reduce wasted travel, others have reported additional benefits of Lean laboratory workflow design, including optimized workflow, improved staff productivity,
error reduction, and quality improvement.\textsuperscript{3-8,12} As expected, we were able to reduce wasted travel by improving the workstation layouts. We anticipate that reduced travel will result in improved laboratory worker productivity (increased tests performed per full-time equivalent per year) because the worker will spend more time at his or her workstation conducting tests as opposed to traveling away from the workstation to obtain items or perform other tasks. However, until the new building is fully operational, we will not be able to realize these benefits. We also anticipate that the adjacencies requested and incorporated into the new building designs will further reduce unnecessary travel. Quality defects were not a major emphasis for us and were not tracked as a primary outcome, in part because we were evaluating multiple workflows during each 2-day kaizen event, each having its own set of potential defects and quality measures. Evaluation for quality improvements in our own laboratory work areas will similarly require further study after full implementation in the new building.

We used the output of these events to inform design and layout of laboratory workstations in a newly constructed building. We believe that the activities presented herein markedly improved efficiencies for the workflows evaluated, but we also recognize that laboratory medicine is not static. New tests and technologies are being developed and these, in addition to laboratory growth, will lead to further changes in the work process steps and ideal work area design. In anticipation of future changes and the flexibility those may require, we have also incorporated configurability into the workstations by selecting mobile laboratory casework that can be reconfigured as needed to support future work area revisions.

We further analyzed one laboratory (immunopathology) to better understand the steps requiring travel during the technologist’s workday. We chose this area because the percentage of steps outside the optimal work area for this area (37.9\%) was very close to the mean value for the 4 areas analyzed (38\%), and therefore this area most likely was representative of our laboratories. We found that the time required for a technologist to travel outside the optimal work window ranged from an average of 8 seconds for locations more than 5 to 25 feet away to 70 seconds for locations more than 75 feet from the worker. Although in the present study, we focused on eliminating each travel event, clearly the effect varies based on how far the technologist is traveling. A future improvement event may focus on reduction of distance for the remaining work steps requiring travel. Of course, productivity improvements will require that the time previously spent in travel is reallocated appropriately toward testing. Put another way, if the time previously wasted in travel becomes wasted in another activity, then no productivity improvements will be seen.

Our experience is similar to those of others in that Lean tools were effective in reducing wasted travel in the laboratory. The tools we applied are not unique; others have used kaizen, standard work, and spaghetti diagrams, and even created models allowing participants to confirm or revise the layout.\textsuperscript{3,5,6,12} Like others we found that the tools are effective in reducing waste. Although the consistent successes reported may be in part the result of publication bias, data from many industries support Lean as a useful tool for eliminating waste and improving workflows. Our experience is unique insofar as it is the first report of Lean laboratory redesign that has applied a common approach to evaluating and redesigning this large number of unique workflows spanning 4 different laboratories. Like other laboratories we included front-line employees in the improvement events. This respect for and involvement of the worker and solicitation of the worker’s input is an important aspect of Lean. Our events were also notable for including such a large number of laboratory workers (67) to acquire a wide range of inputs. This large number of participants also allowed us to generate several ideas beyond the scope of the current project that can be evaluated in future efforts.

An unusual feature of our approach lies in our facilitators. Some articles on laboratory process improvement describe enlisting the assistance of consultant groups,\textsuperscript{4,5} “central” organizational resources,\textsuperscript{6} and/or local employees receiving specialized training\textsuperscript{4,6,8} to facilitate improvement activities. Rutledge et al\textsuperscript{5} noted that their group applied what they learned during their laboratory design initiative to improve other sections of the laboratory without consultants, indicating that they also gained internal capability with the use of Lean tools. In our case, the kaizen events were facilitated by process engineers with manufacturing experience who are full-time employees of the laboratory. By employing individuals with these skills in our organization, we incur associated salary and benefits costs but avoid consulting fees. In our experience, having these individuals “embedded” in our laboratory has allowed us to rapidly build buy-in, create culture change, and build capability in multiple areas of the laboratory. We are optimistic that in time we will build significant capabilities so that an increasing number of individuals in our laboratory will be able to do this work.

A limitation of the present study is the lead time between the improvements and full implementation and use of the new designs in the new building. The events reported herein were initiated and completed in 2009, and the new building is scheduled to be fully operational in early 2012. It is possible that alterations in workflow will have occurred between completion of the events and activation of the new building. Fortunately the configurable workstations allow us to adapt to evolving demands and continually reduce wastes.

In conclusion, we present an approach to laboratory design that leveraged Lean tools and laboratory technologist knowledge through a collaborative process to redesign 68...
workstations. The revised designs reduced technologist travel and thereby improved utilization of technologist skills. Additional benefits include definition of work steps in standard work charts, improved laboratory workstation adjacencies, and identification of additional process improvement opportunities in our laboratory.

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References