Inpatient Preanalytic Process Improvements

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Preanalytic process problems are a well-recognized source of clinical complaints and probably cause the most identification errors.1–4 As the primary patient contact with the clinical laboratory, phlebotomy is especially important to the quality image of laboratory services for patients, clinicians, and other health care professionals. Clinical laboratories have always been interested in improving the services provided to their customers. Clinical laboratories were early users, for example, of statistical control charts, such as X-bar (averages) control charts and p (proportion) charts for investigating preanalytic problems. The College of American Pathologists expanded quality studies to include multilaboratory surveys, as demonstrated by Q-probes (evaluating quality improvements in laboratories) and Q-tracks (Q-probe studies redesigned into longitudinal monitors).5,6 A continuing interest in improvement persists in the clinical laboratory community today.

Additional quality tools have recently been added to the list of possible aids for quality improvement projects. Among the tools that began to be widely applied in the past 10 years were those related to Lean (Toyota, Aichi, Japan), Six Sigma (Motorola, Schaumburg, Illinois), and Failure Mode and Effects Analysis (FMEA). Lean projects are initiatives focused on eliminating all waste in manufacturing processes.7 Principles of Lean manufacturing include reducing waiting times (for collection and transportation), scheduling (dispatch mode rather than a dedicated staff), batch to flow (responding to individual collections and reducing batches of samples held before transportation), and line balancing (evenly distributing the blood draws among available phlebotomists).7 Six Sigma methods focus on reducing variance (of responsiveness time and defects like incident reports) in processes to improve their capability.7 The FMEA process is a systematized group of activities to recognize and evaluate the potential failures (delays) of a process, their causes and their effects, and actions that could eliminate or reduce the occurrence of the potential failures.7 In one recent survey,6 the Six Sigma design phase and SIPOC (suppliers, input, process, output, and customers) tools were applied to determine the high-risk steps for phlebotomy. That survey demonstrated that the highest risk priority number scores were associated with...
preprinted, nonbarcoded admission labels and with comparing hospital information orders with patient wristband identification. Tools used in that survey included the fishbone diagram, process mapping combined with FMEA, and the SIPOC approach. However, that project looked only at the design phase. The question remains as to how successful these widely discussed tools actually perform in the full implementation of a quality improvement project. The quality improvement steps described here show the results of full use and analysis with these now-standard and familiar quality tools in the clinical laboratory.

**MATERIALS AND METHODS**

Inpatient phlebotomy at the University of Texas MD Anderson Cancer Center (Houston) is performed primarily by phlebotomists (approximately 80% of all blood draws) in the General Services Section within the Department of Laboratory Medicine. It is a 24-hour operation, serving 689 inpatient beds and includes the intensive care unit and emergency center services to oncology patients. The participants in the project included the department chair (sponsor), the clinical administrative director, and 2 supervisors in phlebotomy. The project director was the director of the Pathology and Laboratory Medicine’s Quality Improvement department, who was assisted by 2 quality technologists and an industrial engineer from the MD Anderson Office of Performance Improvement. The group aligned the project with 2 of the institution’s strategic goals: (1) to increase the quality, safety, and value of clinical care; and (2) to enhance productivity, access, and efficiency by strengthening the infrastructure and support system.

The scope of the project focused on timely responsiveness when phlebotomists are dispatched for STAT and routine blood draws. The data include both specimens that were walked to the laboratory and those that were sent by pneumatic tube system. Because the routine morning collections done for daily rounds and the intensive care unit areas were performed by staff dedicated to those certain areas, those data points were excluded. Baseline data were established for the periods from requested collection time to actual collection time and from collection time to log-in in the specimen laboratory during a 3-month period (February 2011 to April 2011). Baseline raw data were collected electronically as follows: (1) response time from request to collection was, on average, 21.5 minutes; (2) response time from collection to log-in in the laboratory was, on average, 33.5 minutes; and (3) the number of laboratory-related, inpatient incident reports reported from January 2010 to December 2010 totaled 308.

The laboratory-related incident reports filed in the electronic event reporting system at MD Anderson Cancer Center were evaluated with Pareto analysis. For the period of January 2010 through December 2010, 308 of 388 laboratory incidents (79.4%) were from inpatient areas. The harm levels of the incidents were categorized using the National Coordinating Council for Medication Error Reporting and Prevention Index for Categorizing Medication Errors. Missed laboratory tests, timing of collections and delays, and laboratory order-entry errors made up 83% (256 of 308) of all laboratory-related incidents. All of these incidents were theoretically addressed by the proposed quality improvement project. Figure 1 shows the categories of laboratory-test-related incidents in a Pareto diagram.

In the next step, team members met with external departments and observed the processes and developed a value stream map (Figure 2). They identified the potential sources of delay and redundancies using a fishbone diagram (Figure 3). The causes were categorized as follows: (1) communication, (2) transportation, (3) materials/equipment/systems, (4) staffing, (5) methods, and (6)
working environment. Some examples of issues related to each of these categories are shown in Table 1. The team then used an FMEA to define risk priority numbers for the 69 possible causes they identified (a portion of that is shown in Figure 4).

The team used the ranked causes to identify 75 possible short- and long-term solutions for the higher-ranking risk priority numbers. These solutions were ranked according to the solution-prioritization matrix for implementation. The team has implemented 11 of those solutions as follows: (1) changing the pending laboratory query to enhance the number of pending collections seen and controlled by the phlebotomy dispatch personnel, (2) communicating the new dispatch process to nursing management, (3) training the dispatchers on using the new dispatch process, (4) piloting of the new dispatch process, (5) implementing a dispatch service to all inpatient service areas, (6) acquiring enough pagers that each phlebotomist has one (rather than sharing by shift), (7) standardizing the labeling and education regarding the use of pneumatic tube system, (8) adjusting staffing start times, (9) consolidating all label printing from the unit areas to dispatch, and (10) training clerical floor staff regarding laboratory priorities, test codes, laboratory order entry times, and labeling of print schedules. All of these activities occurred between March 2011 and July 2011. We also developed and implemented a computerized dispatch database to track pending collections and personnel.

X-bar charts were used to group the raw data for all creatinine tests ordered each week; the charts were “staged” according to when process changes were made. The upper and lower control limits were defined as 3 SD, were recalculated for each week’s data point, and were centered from the mean for the applicable stage. Student t tests (using 95% confidence intervals and not assuming equal variances) were used to evaluate the statistical significance of the difference in the means. These charts and analyses were performed using Minitab software (release 14.20, Minitab Inc, State College, Pennsylvania).

RESULTS

After the interventions, the response time from request to collection was decreased by 23% (from 21.5 to 16.6 minutes). This reduced the wait time per week for phlebotomy by 343 hours (4222 blood draws per week). The stepped approach, with pilot baseline data and after full implementation, is shown in Figures 5 and 6. The mean difference was 4.9 minutes ($P < .001$).

The response time from collection to laboratory log-in was decreased by 8% (from 33.5 to 30.8 minutes), as shown in Figure 6, which reduced the laboratory wait time per week by more than 190 hours (4222 blood draws per week). The $t$ test estimate for the difference of was 2.7 minutes ($P < .001$).

The number of incidents reported that were within the scope of the project showed a decrease in the weekly trend compared with those in 2010 (4.9 incidents/wk). These incidents, which were 83% of all laboratory incidents at baseline, were now only 42% (3.0 of 7.1 incidents per week) of the incidents. The new rate was 3.0 incidents/wk, with a $t$ test estimate for the difference of 1.9 events ($P = .04$). Incidents related to delays, missed laboratory collections, and timing of collections were reduced by 43% (from 14 per month to 8 per month).

In addition, a satisfaction survey queried the inpatient service coordinators regarding their satisfaction with the new phlebotomy dispatch process. They were asked to compare how they felt about the process, their impression of phlebotomist response times, the number of problems encountered with the process, and the number of phone calls required to request a phlebotomist for blood collection.
The results of this survey showed a marked improvement in the satisfaction of clerical personnel. Improved communication between laboratory phlebotomists and clerical staff probably contributed to these results in the satisfaction survey. The survey results are shown in Figure 7.

**CONCLUSIONS**

During the past 20 years, many studies have examined laboratory turnaround times as one of the most prominent signs of laboratory service. Turnaround time is often used as a key indicator of quality, despite the lack of indication...
that decreased turnaround time improves patient care or hospital length-of-stay.\textsuperscript{11} For therapeutic turnaround time, reducing preanalytic delays through faster sample transport and delivery is probably the single, most important improvement.\textsuperscript{10} Most problems within clinical laboratories are associated with preanalytic steps.\textsuperscript{1-4} An early evaluation by Howanitz and Schifman\textsuperscript{12} suggested that phlebotomy services would probably achieve their greatest gains by

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**Figure 4.** Potential sources of delays and redundancies. Abbreviations: CVC, central venous catheter; Feb, February; LLT, laboratory liaison technician; RPN, risk priority number.

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**Figure 5.** X-bar chart of trends in response time for requests to collect blood for creatinine test in all inpatient areas for all orders between 6:00 AM and midnight on weekdays only. Abbreviations: LCL, lower control limit; UCL, upper control limit; X-bar, average.

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Figure 6. X-bar chart of turnaround times from collection to log-in in laboratory. Abbreviations: LCL, lower control limit; UCL, upper control limit; X bar, average.

Figure 7. Inpatient service coordinator satisfaction survey. Old versus new dispatch process. Abbreviation: N, total number of survey responses.
focusing on specific processes and administrative inefficiencies. Unhappiness with turnaround times remains a problem today. A 2006 report of a College of American Pathologists Q-probes survey of nursing satisfaction with clinical laboratory services indicated that respondents were least satisfied with issues related to turnaround time, including phlebotomy responsiveness to service requests.

Traditionally, laboratories have approached these problems with an episodic approach, which included full evaluation of incidents, followed by corrective actions. More recently, industrial engineering quality tools, such as Lean, Six Sigma, and FMEA, have been implemented in the health care environment. Results from these processes indicate that the procedures with the highest risk were linked to the administrative aspects of phlebotomy and included accuracy of patient identification with preprinted, nonbarcoded admission labels, when compared with the hospital information orders using identification by patient wristband. However, that study looked only at the design phase and not at the total process improvement of the project. Another institution used retrospective root cause analysis to investigate the role of phlebotomy in an emergency department and determined that, among the delays was order-processing time, which was addressed with a dedicated phlebotomist for the emergency department.

As exposure to these tools has penetrated health care, a common question has been their applicability to the more-varied and economically constrained environment of the clinical laboratory. This quality improvement project demonstrates real value for these various tools when applied in a large medical center.

This project was designed to fully assess delays and issues in phlebotomy in an institution currently functioning without a wristband barcode phlebotomy system. Identification of areas for improvement were systematically assessed by connecting the tools used, so the outputs of each tool determined the inputs for the next quality tool or improvement-process phase. Various quality tools were used, including statistical control charts, Pareto diagrams, a value stream map, a process FMEA, a fishbone diagram, a solution prioritization matrix, and a customer satisfaction survey (Figure 8). Sequential use of these tools ascertained that all relevant areas for improvement were identified and retained the emphasis on process improvement.

Through these efforts, the preanalytic, inpatient, laboratory responsiveness time (response time from request to collection) was decreased by 23% (from 21.5 to 16.6 minutes). The response time from collection to log-in in the laboratory decreased by 8% (from 33.5 to 30.8 minutes). These results demonstrate that a concerted and thorough application of quality tools can drive process improvement to a targeted quality goal in an active clinical laboratory setting. Other laboratories may wish to select the most useful tools to match their project size and resources. However, this project clearly demonstrates the value of such tools in assessing the circumstances of problems. In addition, it demonstrates the value of challenging the project results with statistical control charts already familiar to most laboratory professionals, as recommended in a

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**Figure 8.** Connecting the tools: Abbreviation: FMEA, Failure Modes and Effects Analysis.
recent comprehensive review of laboratory turnaround times.\textsuperscript{10}

Improved preanalytic processes undoubtedly contribute to patient safety. Patient safety will likely continue to be a focus for the Joint Commission.\textsuperscript{15} States have also recently passed legislation requiring the reporting of patient safety incidents that result in significant harm or death. Thorough review of the preanalytic processes in the clinical laboratory for efficiencies and safety is an important mechanism by which the clinical laboratory can contribute to a safe, efficient, and patient-centric environment.

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References