Significant Reduction in Preanalytical Errors for Nonphlebotomy Blood Draws After Implementation of a Novel Integrated Specimen Collection Module

Rachel D. Le,1 Stacy E. F. Melanson, MD, PhD,2,3 Athena K. Petrides, PhD,2,3 Ellen M. Goonan, MS, MT(ASCP)SH, RN,2 Ida Bixho,2,4 Adam B. Landman, MD,3,5 Anne Marie Brogan, MSN, RN,6 David W. Bates, MD, MSc,3,6 and Milenko J. Tanasijevic, MD, MBA2,3

From the 1University of Massachusetts Medical School, Worcester, MA; 3Harvard Medical School, Boston, MA; and Departments of 2Pathology, 4Emergency Medicine, 5Nursing, and 6Medicine, Brigham and Women’s Hospital, Boston, MA.

Key Words: Preanalytical errors; Patient safety; Information technology; Nursing collections

ABSTRACT

Objectives: Most preanalytical errors at our institution occur during nonphlebotomy blood draws. We implemented an electronic health record (EHR), interfaced the EHR to the laboratory information system, and designed a new specimen collection module. We studied the effects of the new system on nonphlebotomy preanalytical errors.

Methods: We used an electronic database of preanalytical errors and calculated the number and type of the most common errors in the emergency department (ED) and inpatient nursing for 3-month periods before (August-October 2014) and after (August-October 2015) implementation. The level of staff compliance with the new system was also assessed.

Results: The average monthly preanalytical errors decreased significantly from 7.95 to 1.45 per 1,000 specimens in the ED (P < .0001) and 11.75 to 3.25 per 1,000 specimens in inpatient nursing (P < .0001). The rate of decrease was similar for mislabeled, unlabeled, wrong specimen received and no specimen received errors. Most residual errors (80% in the ED and 67% in inpatient nursing) occurred when providers did not use the new system as designed.

Conclusions: Implementation of a customized specimen collection module led to a significant reduction in preanalytical errors. Improved compliance with the system may lead to further reductions in error rates.

Laboratory test results contribute to an estimated 70% of patient care clinical decisions.1 In the past few decades, there has been considerable focus on laboratory errors, especially those originating in the preanalytical phase (eg, patient misidentification, inappropriate tube type, improper specimen handling). These common types of errors have the potential to negatively affect patient care by leading to missed or delayed diagnoses or inappropriate treatment.2-13 In contrast to analytical and postanalytical errors, preanalytical errors are often hard to prevent with process improvement interventions, since multiple manual processes and personnel with varying levels of training and skill sets are involved.

Significant efforts have been made to understand and decrease preanalytical errors. Turner et al14 described a dramatic decrease in the total number of preanalytical errors (P < .001) (eg, wrong tube type, mismatch of patient identification [ID], and specimens sent to the incorrect laboratory discipline) in the primary care setting following the introduction of an electronic system that generates a specimen label with collection instructions (eg, specimen tube type and location to send the specimen). Lillo et al15 observed a two- to threefold decrease in all measured preanalytical errors (eg, clotted, hemolyzed, insufficient, and uncollected specimens) as well as an increase in patient satisfaction after the implementation of a custom label and nursing education program. Snyder et al16 performed a systematic review of 17 studies evaluating specimen barcoding practices at different hospital settings. The review concluded that barcoding is essential for reducing specimen and laboratory testing identification errors and that this practice is generalizable to most hospital settings.
We have done similar work at our institution.\textsuperscript{17} We previously implemented a stand-alone electronic patient ID (PPID) system in inpatient phlebotomy that used handheld devices to confirm patient ID and portable printers to generate bedside labels. The system helped to prevent an estimated 108 mislabeling errors in 1 year. However, the preanalytical error rates remained high for providers and locations not using the PPID system, such as the emergency department (ED) and for inpatient nonphlebotomy draws. Studies on the impact of a fully integrated PPID system on nonphlebotomy preanalytical errors are relatively sparse in the literature.

In May 2015, we had an opportunity to implement a new electronic health record (EHR) that interfaced with the recently implemented laboratory information system (LIS). As part of this effort, we designed a modified specimen collection module for nonphlebotomy draws. In this study, we describe the new module and determine if it led to a reduction in the most common preanalytical errors. To our knowledge, we are the first institution to implement this modified electronic specimen collection module and to assess its impact on preanalytical errors.

Materials and Methods

Study Site

This study was performed at the Brigham and Women’s Hospital, a 777-bed, tertiary care center located in Boston, Massachusetts. In November 2014, our laboratory implemented a vendor LIS, Sunquest (Sunquest Information Systems, Tucson, AZ). In May 2015, our institution implemented a new EHR, Epic (Epic Systems, Madison, WI), which had a bidirectional interface with our LIS.

At our institution, approximately 60\% of inpatient specimen draws are performed by phlebotomy, while the remaining 40\% are drawn by nursing. Nurses draw all patients with central lines. In the ED, most blood draws are performed by nurses. Emergency service assistants and physicians occasionally draw patients in the ED but work in collaboration with nursing, who assists with patient and specimen identification.

Nonphlebotomy Specimen Collections and Test Ordering Preimplementation

Prior to May 2015, laboratory tests were ordered electronically using templates and/or the physician order entry (OE) system or written directly onto paper requisitions. There was no interface between the OE system and the LIS. Thus, all electronic orders were eventually transcribed onto paper requisitions and sent to the laboratory to be manually entered into the LIS. Nurses used a paper requisition and specimen labels printed from the hospital information system when collecting the specimens. The labels contained two patient identifiers but were not barcode readable by the LIS. In addition, neither the requisition nor the label provided specimen collection information such as the appropriate tube type. If there was a question about collection requirements, the nurse would call the laboratory staff for clarification.

Nonphlebotomy Specimen Collections and Test Ordering Postimplementation

Since implementing Epic in May 2015, laboratory orders have been placed electronically in the EHR and directly transmitted to the LIS, thus eliminating most paper requisitions. Our LIS vendor offered an electronic PPID solution for specimen collection, called Collection Manager (Sunquest Information Systems). This product supported our phlebotomy workflow but was not optimized for nursing workflow. We worked closely with the LIS and EHR vendors to modify the LIS specimen collection module to better accommodate the workflow for nonphlebotomy collections, to increase efficiency, and to reduce errors. The LIS vendor refers to the modified collection module described in detail below as “Label Verify.”

Unlike phlebotomists, nurses do not have carts stocked with collection supplies that they take into the patient’s room. Instead, nurses gather the supplies necessary for one specific patient prior to entering the room. Therefore, the nurses decided it was important for the labels to print at a central location so that they knew prior to entering the room which tubes were necessary. To mitigate the risk of potential mislabels that may occur when multiple patients’ specimen labels are printed to a single centralized label printer, we designed and purchased a modification of the vendor’s existing product (henceforth referred to as a new or modified “specimen collection module”) that would allow the nurse to scan the labels against the patient wristband at the bedside. If a mismatch occurred, the nurse would be notified immediately and prompted not to draw the patient. \textbf{Figure 1.} Furthermore, this solution avoids the need to place label printers in every patient room and more closely aligns the specimen collection workflow with the barcode-based medication administration workflow.

Pending collections are viewable in the worklist in the EHR (Figure 1). When nurses are ready to collect a specimen, they click the “print label” task, which triggers a LIS-readable label to print. The labels contain patient identifiers and collection instructions, including the test(s) ordered and tubes required. Nurses bring all venipuncture supplies, including the barcoded LIS specimen labels into the patients’ room. The patient wristband and specimen labels are scanned...
to verify patient and specimen identification (also referred to in the article as “PPID portion”). The EHR records successful PPID or alerts the nurse of a mismatch. It also records the date/time and person who collected the specimen. While there is no way to ensure that the nurse scans the labels against the patient wristband prior to the blood draw, there is an audit function in the EHR to track compliance.

### Assessment of Preanalytical Errors

Our retrospective analysis was conducted using an existing database that contains a monthly tally of preanalytical error types, including mislabeled and unlabeled specimens, no specimen received, and wrong specimen received. Generally, errors are detected by laboratory processing personnel during specimen receipt. When an error is detected, laboratory personnel file incident report forms, which document the type of error, location of the blood draw, specimen accession number, and department contact information. We used this database to extract and summate the number of preanalytical nonphlebotomy errors in the ED and inpatient nursing recorded between August and October 2014 (ie, preimplementation) and August and October 2015 (ie, postimplementation). We started data collection in August to allow 2 months for training and stabilization on the new specimen collection module. In this article, we focus on the top four types of errors: mislabeled specimens, unlabeled specimens, no specimen received, and wrong specimen received. The total number of specimens collected in the ED and inpatient nursing was downloaded from the LIS, allowing us to normalize the data and calculate the number of each error per 1,000 “specimen tubes collected” (henceforth referred to as “specimens”). While total specimen volumes and the total number of personnel drawing laboratory specimens did not change before and after implementation, the categorization and distribution of specimens as collected by ED and inpatient nursing changed slightly; this was because ordering locations were translated differently by the new EHR. To account for this change, we translated the postimplementation specimen volumes using the original, preimplementation categorization. For example, if 30% of all specimens were collected in the ED preimplementation, we multiplied the total volume postimplementation by 0.30 to obtain the ED-specific volume postimplementation.

### Compliance Data

To determine compliance with the new specimen collection module, reports were downloaded from the EHR. All errors postimplementation were reviewed to determine if the nurse performed PPID and scanned the wristband against the specimen label. Overall compliance was assessed for representative days and weeks postimplementation (August 16-22, 2015; September 1-10, 2015; September 14-21, 2015; September 29 to October 7, 2015; October 16, 2015; October 20, 2015; October 26, 2015; and October 29, 2015).

### Data and Statistical Analysis

We calculated overall compliance with the new specimen collection module. We also calculated average rates of preanalytical errors per 1,000 specimens. Errors rates were compared before and after implementation of the modified specimen collection module using Fisher’s exact test. $P \leq .05$ was considered statistically significant. Errors postimplementation were reviewed to determine if nurses were compliant with the new specimen collection module.

### Results

#### Overall Compliance Data

Overall compliance with the new specimen collection module for nonphlebotomy draws during representative
The mean monthly volume of preanalytical errors pre- and postimplementation. **A**, The mean monthly errors per 1,000 specimens of the top four preanalytical errors (ie, mislabeled specimens, unlabeled specimens, no specimen received, and wrong specimen received) in the emergency department are shown before (August-October 2014) and after (August-October 2015) implementation. **B**, The mean monthly errors per 1,000 specimens of the top four preanalytical errors (ie, mislabeled specimens, unlabeled specimens, no specimen received, and wrong specimen received) in inpatient nursing are shown before (August-October 2014) and after (August-October 2015) implementation. $P < .05$ for all error categories when comparing postimplementation with preimplementation.

**Discussion**

In this study, we assessed the impact of an interfaced EHR-LIS system and a novel integrated specimen collection module on the number of preanalytical errors associated with nonphlebotomy draws. We worked closely with the LIS vendor, Sunquest, to custom-develop a modified version of its Collection Manager product to better accommodate the workflow for nonphlebotomy collections.

Our analysis showed that the new specimen collection module significantly decreased the number of mislabeled and unlabeled specimens. An investigation of the residual mislabeled and unlabeled specimens postimplementation revealed that most were due to noncompliance with the system. In 83 or 92% of these cases, the nurses did not scan the labels prior to collecting the specimens; therefore, they were not compliant with the process as designed. The four unlabeled specimens that occurred despite following the correct procedure may have been due to the provider forgetting to label the specimen after collection. It is unclear why mislabeled specimens occurred despite compliance with the new system.

The number of no specimen received and wrong specimen errors also decreased significantly. The interface between our LIS and EHR enabled the correct number of LIS labels to print in the patient care areas. Furthermore, we
designed our labels to contain an abbreviation for the correct tube type to draw (eg, LAV for lavender or purple top) as well as other collection information to guide the providers on the number and type of tubes to bring into the patient’s room. These tools explain the dramatic reduction in the number of no specimen and wrong specimen received errors. The remaining incidents of no specimen or wrong specimen received errors may be due to the fact that the abbreviation was not clear to the provider or that the wrong number of labels printed due to a technical problem in the LIS. We have examined these errors and made changes to our LIS, including modifying the specimen combining logic to further reduce the number of no specimen and wrong specimen received errors, as evidenced by a downward trend in the postimplementation numbers over the 3-month period (data not shown).

Compliance with the new specimen collection module has been challenging due to the steep learning curve associated with the new EHR and changes to many clinical workflows. Technical challenges in the first few months also slowed adoption of the system as nurses felt more comfortable reverting to old processes. However, the system’s audit functionality allowed us to design several approaches to improve compliance. Nursing educators and directors have followed up directly with staff to obtain their feedback and remind them of the importance of using the system as designed. Retraining has been performed in targeted areas featuring higher noncompliance. In addition, some units have posted anonymized compliance rates and peer-to-peer comparison to encourage appropriate usage. We are currently exploring the possibility of disabling the system’s acceptance of generic EHR admission discharge transfer labels as PPID compliant, one of the potential ways to circumvent the system. We will continue to track overall compliance with a goal of 90% in all areas.

We plan on expanding the new specimen collection module to the outpatient nonphlebotomy collection areas. This is predicated upon the implementation of barcoded wristbands for ambulatory patients. The new module may also be useful in other areas that do not have a robust patient and specimen identification process.

As our study was performed in a single academic center in a specific geographic region, the results may not be generalizable to other types of centers or regions featuring different systems and processes for blood draws. However, the new specimen module we describe could be successfully implemented in hospitals of varying sizes if the process fits their workflow. We may have underestimated the number of mislabeled and unlabeled specimens postimplementation as our specimen-processing area no longer receives paper requisitions with which to compare the specimen labels. However, we expect the underestimation to be low since we have received only a few complaints from clinicians about possible inaccurate results (these cases were included in the errors tally postimplementation). In addition, the mechanisms in place in the analyzing laboratory to detect erroneous results such as delta check flags did not reveal an increased number of errors postimplementation. Another limitation of the study was that we are unable to determine the root causes of some of the errors postimplementation because we did not monitor the errors in real time. Finally, we elected to normalize preanalytical errors per 1,000 specimen tubes collected. As described in the Materials and Methods, we recorded the errors per blood draw/requisition received (eg, if two tubes were mislabeled during a single specimen draw, we recorded it as a single error event). Since we receive an average of two tubes per requisition, the number of errors both pre- and postimplementation may have been underestimated twofold.

We conclude that an interfaced LIS-EHR with an internally designed, custom-developed specimen collection module can significantly decrease the number of nonphlebotomy preanalytical errors in the ED and inpatient setting. Further interventions are needed to optimize the format and number of printed specimen labels and to improve staff’s compliance with using the new system.

Corresponding author: Milenko J. Tanasijevic, MD, MBA, Brigham and Women’s Hospital, 75 Francis St, Amory 2, Boston, MA 02115; mtanasijevic@partners.org.
Partners Healthcare paid Sunquest to design and develop the modified specimen collection module. Sunquest did not participate in the design, conduct, analysis, or write-up of this study.

Acknowledgments: We thank Tanika Patterson and Maureen Elmes for their hard work reviewing all the incident reports, as well as Lyman Garniss, Larry Riley, and Jenni Theriault for their technical expertise and work with the vendor to develop the customized specimen collection module.

References


