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Improving the Nursing Practice Environment With Point of Care Specimen Collection

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This is to certify that the doctoral study by

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Abstract

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MS, University of Maryland, Baltimore, 2004

BSN, Towson University, 2001

Project Submitted in Partial Fulfillment

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Abstract

Specimen collection and identification errors are a significant problem in healthcare, contributing to incorrect diagnoses, delayed care, lack of essential treatments, patient injury or death, increased length of stay and increased healthcare costs, and decreased patient satisfaction. The purpose of the project was to evaluate the implementation of specimen collection technology with barcode scanning and bedside label printing in the maternal child health division of a community teaching hospital. The project was driven from Donabedian's quality framework for healthcare implementations, indicating that evaluating the quality of health care can be drawn from the categories of structure, process, and outcomes. The project featured a quantitative analysis with a pretest-posttest design. Mislabeled specimen rates and collection turnaround times were generated from laboratory quality data and measured before, during, and after implementation of specimen collection technology. Data analysis using an independent samples *t* test in SPSS 17.0 compared the changes in the mean scores of specimen collection turnaround times and mislabeled specimen rates. Mislabeled specimen percentages in all areas decreased from 0.0250% preimplementation to 0.0023% postimplementation with a *p* value less than 0.001. Collection turnaround times greater than 60 minutes decreased following implementation of specimen collection technology by 22% with a *p* value less than 0.001. The implementation of specimen collection technology has positive implications for social change, including the expectation that as technology is proven to significantly improve the safety and quality of laboratory collections, there will be a mandate for implementation of safer collection processes in healthcare.

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Section 1: Nature of the Project

Introduction

There has been a recent focus in healthcare on the prevention of medical errors that have a significant impact on patient outcomes. According to the Institute of Medicine (2001), technology plays a pivotal role in creating systems that are inherently proficient at reducing preventable errors. The current literature has indicated that specimen identification error rates in systems that do not use technology range from 0.1% to 7% (Howanitz, Renner, & Walsh, 2002), which constitutes a serious problem, as errors contribute to incorrect and potentially delayed or lack of treatment. Specimen collection and identification errors may cause significant patient injury or disability, longer lengths of stay, increased healthcare costs, diverted resources, and increased patient dissatisfaction (Snyder et al., 2012). It is estimated that over 160,000 adverse medical events each year can be attributed to the misidentification of laboratory specimens (Valenstein, Raab, & Walsh, 2006). In this project, I discuss the evidence-based practice (EBP) implementation and evaluation of an automated specimen collection system with bedside label printing and scanning in a community teaching hospital's maternal child health division. In Section 1, I discuss the basic overview of the EBP, including the introduction, problem statement, purpose statement and project objectives, significance, project question, implications for social change, definitions of terms, and any assumptions and limitations.

Background and Context

The project initiative site was a 300-bed community teaching medical surgical hospital in Baltimore, MD, ranked nationally in the three primary specialties of gynecology, neurology/neurosurgery, and orthopedics. The project initiative site is also ranked as a high

performing facility in the areas of cancer, diabetes and endocrinology, gastroenterology/gastrointestinal surgery, geriatrics, nephrology, and urology. The site is also a Magnet recognized organization, honored by the American Nurses Credentialing Center as one of the top hospitals nationwide for quality patient care, nursing excellence, and innovations in professional nursing practice (American Nurses Credentialing Center, 2016).

When best practice procedures are followed in the laboratory specimen collection process, the chance of mislabeling a tube is close to zero (Harty-Golder, 2001). Despite having defined best practice safety measures in place such as using two patient identifiers, the use of preprinted patient chart labels applied at the bedside, the reliance on a comprehensive specimen collection staff training program, and defined specimen collection policies, there continued to be mislabeled specimens in the community teaching hospital's maternal child health division, equating to approximately one to two specimens per month, or 0.0250%.

Nursing is a dynamic profession where the staff is often pressured to complete activities in a hurry, contributing to the chance that rigid adherence to a policy is challenged in practice. The demand for quick action is often realized in the maternal child health areas, where laboring mothers or critically ill infants require higher levels of care. The previous specimen collection process was time consuming and cumbersome, promoting staff to undertake system workarounds to complete activities faster. It was common for clinical staff to experience inefficiencies in the ordering and specimen collection processes, contributing to questionable specimen collection judgment, such as collecting specimens when placing a peripheral intravenous line before orders are entered in the system and then leaving the tubes at the bedside until the orders are available.

Problem Statement

Incident management system reports indicate that the maternal child health areas at a community teaching hospital were experiencing challenges related to specimen collection and processing. Twenty-seven percent of all specimens in the maternal child health areas took greater than 1 hour to process from collection time to the point where the specimen was received in the laboratory (lab). The process of collecting specimens was cumbersome and error prone, with order acknowledgement, printing of a paper lab requisition, forcing the nurse to stop his/her workflow to convene at a centralized location, and manual labeling at the bedside with chart labels. The labeling of blood bank specimens also required a second nurse at the bedside to verify patient information prior to labeling the specimen and applying a typenex band. It could be difficult to find a second nurse, which contributed to delays in the ability to collect and send a specimen.

Additionally, lab quality data showed that the previous mislabeled specimen rate was 0.0250%, which was greater than the internally developed laboratory suggested best practice benchmark of less than 0.0100%. Mislabeled specimens can have devastating effects on patients, contributing to significant errors in treatments or care, which could lead to patient harm and dissatisfaction (Wallin et al., 2009). There were concerns that the previous specimen collection process promoted work-arounds and contributed to errors in labeling specimen containers if the nurse stepped away from the bedside during the process, with no way to track and audit what was really occurring during specimen collection.

Purpose Statement

The main purpose of the project was to perform an evaluation of the implementation of specimen collection technology capable of providing positive patient identification through the scanning of the patient's wristband with wireless bedside specimen label printing and scanning of specimen(s) to indicate collection date and time. The system evaluation was focused on the maternal child health division of a community teaching hospital. The project purpose aligned with the American Association of Colleges of Nursing's (2006) essentials of DNP education: Information Systems Technology and Patient Care Technology for the Improvement and Transformation of Healthcare. Implementing new specimen collection technology also complimented the facility's nursing strategic plan in the section of evidence, research, and innovation, specifically the goals of nurses defining best practices through the utilization of technology as well as nurses driving change through innovation.

Project Objectives

The two primary objectives that were measured during the specimen collection technology evaluation were related to the mislabeled specimen rate and specimen collection turnaround time. The first project objective was that immediately following the implementation of specimen collection technology in the maternal child health division, the mislabeled specimen rate would fall below the internally developed laboratory best practice benchmark of 0.0100% as measured by laboratory quality data. The mislabeled specimen rate was calculated by the count of total mislabeled specimens per month divided by the total count of specimens collected per month.

The second project objective was that within the first month following specimen collection technology implementation in the maternal child health division, 90% of all specimens would have a collection turnaround time of less than or equal to 60 minutes as measured by laboratory specimen collection statistics. Collection turnaround times represent the time of collection from logging in to the Mobilab application to the point when the specimen was scanned and sent to the laboratory. These times were generated from identifying the two most commonly collected laboratory tests per unit and analyzing all of those specimens the same week each month to determine if they were collected in under or over 60 minutes.

Practice Question

The development of a thoughtful EBP question was essential, as it drove the search for evidence. Evidence-based questions should be specific, allowing for development of search terms that will generate the most relevant evidence (Dearholt & Dang, 2012). The practice questions should also clearly define the target population to assist in translation of the recommendations. The practice question in population, intervention, comparison, and outcome format was how does implementation of a positive patient identification /automated specimen collection system as compared to manual labeling of specimens with chart labels and paper requisitions affect the mislabeled specimen rate and collection turnaround times in the maternal child health units at a community teaching hospital?

Significance of the Project

Accurate specimen labeling is critical to prevent patient harm and increased costs of care (Wallin et al., 2009). Ensuring correct patient and sample identification is a goal of the College of American Pathologists and a Joint Commission National Patient Safety Goal (Joint

Commission, 2016; Valenstein et al., 2006). Specimen collection and identification errors may cause significant patient injury or disability, longer lengths of stay, increased healthcare costs, diverted resources, and increased patient dissatisfaction (Snyder et al., 2012). In addition to these national stakeholders, local stakeholders include the nursing and nursing support tech staff, nursing leadership, nursing informatics, the information technology department, project management, the laboratory staff, laboratory information analysts, laboratory leadership, nursing and laboratory quality representatives, physicians, and patients.

The project initiative site's maternal child health division had been experiencing greater than acceptable rates of mislabeled specimens and longer than desired collection turnaround times. By introducing scanning of patient wristbands to positively identify a patient that linked to ordered lab specimens that were then scanned and labeled at the bedside, there was large potential in improving the specimen collection process. The implementation ensured that patients and specimens were identified in the least error prone way possible, preventing erroneous results and potential patient harm.

Reduction of Gaps

The original specimen collection practice involved using patient chart labels and printed lab requisition forms. The process involved the nurse verifying the patient identity verbally and reviewing the paper requisition form to identify what specimens needed to be collected, then applying the chart labels on the specimen containers. If the process was not followed specifically, there were multiple steps where errors could occur. Blood bank specimens were even more involved, requiring two nurses at the bedside reviewing and labeling a special blood

bank requisition and typenex bracelet. There was no way to ensure the correct processes were being followed or prevent errors from occurring.

In contrast, when using the Iatrics Mobilab specimen collection system, the patient wristband was first scanned to initiate the process. Once the patient identification was verified, the system showed the lab tests ordered for the patient and printed the specimen labels in the room at the bedside on a wireless label printer. Without patient verification, there was no way to force the labels to print. The only way for the system to fail was to not use it entirely. These safety mechanisms were what drove the accurate identification and labeling practice. During the implementation phase, the laboratory staff was trained not to accept specimens that were not collected using the new system to prevent workarounds from occurring. The only time this would be permissible was during a system downtime or code situation.

Using the original specimen collection processes, 27% of all specimens in the maternal child health areas took longer than 1hour to process from collection time to the point where the specimen was received in the lab. The practice of printing requisitions, obtaining patient chart labels, and having to locate another nurse and verify patient identity with for blood bank specimens could be time consuming and frustrating. The nurse also had to remember when to write certain information on the chart labels, such as the site of a blood culture draw, to assist in researching suspected sepsis cases. Additionally, as the laboratory equipment used barcode readers, each specimen labeled with a chart label needed to be relabeled with a barcode sticker upon arrival to the laboratory. It was not uncommon to see piles of specimens bagged and waiting for new labels at busy collection times in the lab.

Using the new Iatrics Mobilab specimen collection system, each exact step in the process was tagged with a timestamp in the system, which made it easier to identify where the delays were occurring in the collection process. The ease of having all specimen information at clinician fingertips along with container types and order of collection specified saved time and effort from the nursing and phlebotomy staff. The safety checks in the system also allowed for a change in blood bank specimen collection policy, no longer requiring a second nurse in the room at time of collection to verify the process. The ability to demand print barcode specimen labels at the bedside as part of the process also meant there was less time spent looking for chart labels and paper orders and less time for the lab in scanning in specimens, as they no longer had to relabel every specimen that arrived in the lab. All of these features together had the capability of maximizing efficiencies and reducing the time spent in the collection process.

Implications for Social Change

Walden University (2016) defined social change as the "deliberate, process of creating and applying ideas, strategies and actions to promote the worth, dignity, and development of individuals, communities, organizations, institutions, cultures, and societies. Positive social change results in the improvement of human and social conditions" (p. 1). Implementing a specimen collection system that fostered positive patient identification with bedside labeling and scanning reduced the chances that specimens would be labeled incorrectly, contributing to misdiagnosis, incompatible blood transfusions, delayed treatment, or treatment decisions based on incorrect information. It also streamlined the specimen collection process, reducing time from collection to laboratory result and removed process inefficiencies that could contribute to errors. Other reported benefits to implementing specimen collection technology include improved

communication between nursing and laboratory staff, increased patient satisfaction, increased compliance with required elements on the specimen label, and increased ability to track and monitor the specimen collection process (Brown, Smith, & Sherfy, 2011; Morrison et al., 2010). Overall, this project has the potential to increase the quality and safety of the care provided in a community teaching hospital that serves the greater Baltimore area, which could be transferrable to other similar institutions.

Definition of Terms

Mislabeled specimen: The College of American Pathology defines a mislabeled specimen as one that is not uniquely identified (Clinical and Laboratory Standards Institute, 2011). For the purposes of this paper, a mislabeled specimen is defined as a specimen that was collected from one patient but was labeled with another patient's name or was lacking a specimen label entirely. Mislabeled specimens are important, because if the mismatch was not caught by the laboratory, the error could remain undiscovered until a clinician questioned the results. Mislabeled specimens can be difficult to detect but can have significant consequences.

Specimen collection: According to the Miller-Keane Encyclopedia & Dictionary of Medicine, Nursing, and Allied Health, the term specimen collection means the obtaining of body fluids, secretions, or excreta (as cited in Miller, Keane, & O'Toole, 2003). Specimen collection includes blood, urine, feces, sputum, or drainage. For the purposes of this paper, specimen collection means the collection of blood and body fluids, as ordered from a licensed provider.

Turnaround time: Merriam-Webster (2016) defined turnaround time as the action of receiving, processing, and returning something. The project initiative discusses turnaround time in the context of specimen collection activities. Within this paper, collection turnaround time

means the time the specimen was collected from the patient through the time the specimen was noted as being received in the lab.

Assumptions, Limitations, and Delimitations

Studies are often challenged by conditions or influences that may be difficult to control for. Outlining any limitations, delimitations, and assumptions make it helpful for other scholars to understand the circumstances surrounding the particular project initiative. Delimitations are similar to definitions set as the boundaries of the project (Lo-Biondo-Wood & Haber, 2002). They are options that are under control and accounted for. Limitations are potential project initiative factors the researcher has no means of controlling (Talbot, 1995). Assumptions are things accepted to be true as it relates to the project (Polit & Hungler, 1998).

Assumptions

Several underlying assumptions related to this particular project initiative. The first was that adequate time had been spent prior to implementation to optimize the technology for each specialty area to discuss and define the best processes for each unique workflow. It was critical that key stakeholders were involved in the build/design process so that key workflow decisions could be made. These stakeholders included but were not limited to bedside nursing staff, various levels of nursing leadership, nursing informatics representation, information technology staff including help desk, project managers, and systems analysts, laboratory staff including leadership, end users, laboratory systems analysts, and nursing and lab quality analysts.

The second assumption was that there were enough available wireless scanners and printers to suit the busiest of unit workflows without disruption. The assumption aligned with the idea that adequate funding would be available to support the purchase of required hardware. It

was also imperative that all available technology had been tested and proven in working correctly in the confines of the hospital environment. A robust wireless network needed to be available to handle additional wireless workflow without causing issues or delays in scanning, printing specimen labels, or writing data into the electronic record.

A final assumption was that all end users were given standardized education prior to implementation. Adequate funding needed to be in place to support the paid time for staff training. Once users were trained, they were expected to use the technology at all times following implementation. Understanding that there was a learning curve associated with new technology, all system fall outs were tracked and reported back to the end users in a timely fashion to promote continuous quality improvement.

Limitations

Though every opportunity was taken to design an error free system, the implementation of technology could only be successful if the standard operating procedures were followed. Electronic systems could introduce new sources of error when workarounds are used. There were different types of clinical staff collecting specimens, with varying levels of education and experience that could introduce elements of human error within the system. The project was conducted at a single community teaching hospital, though the units involved had different workflows that could contribute to slight differences in specimen collection processes and workflows. There was also no control over what specific activities were occurring on a given unit on any particular day, and unit census and acuity levels could impact workflow and adherence to system usage guidelines. Additionally, the articles reviewed for this project were

limited to English speaking, which could affect the ability to generalize project findings of collection practices because they vary substantially across international settings.

Delimitations

Project delimitations included the inclusion of participants from only the maternal child health division at the project initiative site, including Labor & Delivery, Postpartum Mother Baby, Newborn Nursery, Pediatrics, and Neonatal Intensive Care Units (NICU). These units were selected as the division had the highest number of incident reports in the system and were deemed to potentially reap the largest benefit from implementing the technology. Another delimitation was the narrowing of the laboratory test data that would be analyzed to only the two most commonly ordered tests from each unit to gather a defined yet manageable sample for turnaround time calculations. The pre and postimplementation turnaround time data for all designated specimens were collected for the third week of each month and compared. Since there were relatively few mislabeled specimens within the hospital, all mislabeled specimens were used to calculate the monthly mislabeled specimen rate.

Summary

Health care providers are required to correctly identify patients and laboratory specimens to ensure that the most efficient care is being provided. Misidentification of laboratory specimens can have disastrous patient consequences, so all possible measures must be taken to ensure safe collection processes. Though original nontechnology driven best practice standards exist in healthcare to ensure the safety of the patient identification and specimen labeling process, they require many steps, which, if missed, could result in misidentified specimens and increased collection turnaround times. The most recent evidence suggests that regardless of department,

positive patient identification systems using barcode technology and wireless bedside label printers can significantly decrease mislabeled specimen rates in hospitals.

Section 2: Background and Context

Introduction

The maternal child health units at the project initiative site were experiencing unacceptable mislabeled specimen rates and higher than desired specimen collection turnaround times. The facility was curious how implementation of specimen collection technology would affect mislabeled specimen rates and collection turnaround times. The purpose of the specimen collection technology project was to evaluate the impact of the implementation of a positive patient identification and automated specimen collection system compared to manual labeling of specimens with chart labels and paper requisitions on mislabeled specimens and collection turnaround times in the maternal child health department. Though many initiatives such as bedside labeling and attempts to control for mislabeled specimens could have an impact on the specimen collection process, these initiatives had only slight measurable and sustainable effects on error rates. Technology has the ability to drive sustainable error reduction immediately upon implementation. The research consistently showed that specimen collection technology was capable of reducing mislabeled specimen rates without slowing collection times, as well as uncovering a host of other desirable outcomes following implementation. In Section 2, I discuss the literature search strategy, specific and general themes identified in the literature review, and an explanation of the theoretical and conceptual framework used.

Search Strategy

A literature search was undertaken using CINAHL and PUBMED databases to locate articles from the years 2000 to 2016 that contained the search terms *specimen collection, barcode, specimen labeling, mislabeling, technology,* and *turnaround time,* using a variety of

search strings and Boolean operators. Additional articles were also found by using the reference section of articles and with the assistance of the library technician at the project initiative site. When searching for literature, it was noted that articles related to specimen collection systems were challenging to find. Over 96 articles were located and considered as part of the literature search. All articles that did not fit the same intervention strategy considered by the project initiative site where patient wristband scanning and wireless label printing was used were excluded. Other articles were found, and though they contained helpful information about the specimen collection process, they were not representative of the processes under consideration at the project initiative site or were not graded as high quality articles and were not used in the literature review.

Four primary source articles were identified that addressed mislabeled specimen rates after implementing an orders-driven, positive patient identification specimen collection system with label printing in or close to the patient room where the patient's wristband and lab labels were scanned with barcode reader technology. The articles were all quasi-experimental studies, thereby classified as Level II strength. Three articles were considered of good quality rating and one considered low quality via the Johns Hopkins Nursing EBP Rating Scale (Newhouse, Dearholt, Poe, Pugh, & White, 2005). One case study reporting collection turnaround time data was also identified. As a case study, it was considered to be graded low in terms of evidence strength and quality, but it was included in the discussion, as it was the only study identified that addressed collection turnaround times, an outcome of interest at the practicum site. Overall, the articles suggested that specimen collection and scanning technology paired with bedside label printing was a valid intervention to consider for improving the overall quality and safety of the

specimen collection process. In the specific literature section, I discuss technology's impact on mislabeled specimen rate reduction and collection turnaround times, while mentioning other associated benefits and considerations identified with the implementation of specimen collection technology.

Specific Literature

Mislabeled Specimen Rate Reduction

Every study analyzed in the literature review showed a marked decrease in specimen mislabeled rates following the implementation of technology, regardless of area or specimen type. Brown et al. (2011) demonstrated a mislabeled specimen rate of 2.02% before the implementation of an automated specimen collection system that decreased to 0.13% after implementation across six different hospital units. The article was rated level II strength and of good quality and reviewed the implementation of a positive patient identification specimen collection system with bedside label printing from a portable wireless printer where nurses and technicians were collecting the specimens. No conceptual framework or guiding theory was identified by the authors. The study was quasi-experimental with a nonequivalent control group with pre- and post-intervention data collection.

Brown et al. (2011) included the use of a study time frame of 1 year before implementation and 1 year after implementation for data collection. One strength of the Brown et al. study was that the mislabeled specimen comparison result was found to be statistically significant with a p value less than 0.001. Study weaknesses included a lack of randomization, which could affect internal validity. The researchers also chose to exclude blood bank samples from the data, which limits the ability to generalize the data as they relate to blood bank

collections (Brown et al., 2011). One final concern with the study was that the pre- and post-test data estimates were generated from different reporting methods.

However, the study by Brown et al. (2011) was the closest representation of the proposed specimen collection processes for the project initiative site, and therefore was of special interest in the review and critique process. There were many similarities identified between the patient population and specimen collection processes of the study facility when compared to the project initiative site, suggesting that the results would be able to be generalized across sites. Though the researchers initially chose to exclude blood bank specimens from the implementation, they later went on to add these specimens to other units that implemented the technology following dramatic drops in mislabeled specimen rates (Brown et al., 2011). Mislabeling of blood bank specimens presents higher risk for patient harm, and with no negative effects associated with including these types of specimens in the implementation, the Brown et al. study suggested that blood bank specimens should be included in the initial technology implementation. The Brown et al. study switched reporting methods for the pre- and post-implementation data, which could affect the validity of the data. In order to avoid this challenge in the translation of the research in my project, I decided to outline a defined method for data collection that would not vary before and after the technology was implemented at the project site. Finally, Brown et al. identified success factors of strong leadership involvement, the importance of involving end users in all stages of the project, and the necessity of having a strong wireless network in place and adequate numbers of equipment to match the unit workflow needs, which would be helpful to include in the project site's implementation.

Along similar lines, Hayden et al. (2008) found a reduction in mislabeled specimen rates following the implementation of specimen collection technology from 0.03% to 0.005%. The quasi-experimental study was ranked of level II strength and of low quality. In this particular implementation, the specimen labels were printed centrally at the nursing station, as opposed to directly at the patient bedside. The authors did not discuss use of a conceptual framework or guiding theory. Hayden et al. included a study time frame of 1 year before implementation and 1 year after implementation. A strength identified in the research was that all possible specimen types were included with the exception of downtime or code related specimens. The results of Hayden et al.'s study were found to be statistically significant with a *p* value less than 0.001.

Weaknesses in Hayden et al.'s (2008) study contributed to the low quality rating in the critique. Lack of participant randomization can contribute to internal validity issues. The barcode labels were printed at the nursing station in the center of the unit, not at the patient bedside, which is deemed a safer process. Also of interest was that there were multiple barcode scanner misreads each month, which was attributed to the armband design. These misreads could have contributed to collection procedures not being properly followed. The implementation was also staged across the year with different units going live at different times, which could make the interpretation of the data somewhat harder to translate. One of the greatest study weaknesses was that the preimplementation method of data collection was not defined, making it difficult to calculate the effects of the study without more details about the comparison group. The study setting was also very distinct, potentially making it harder to generalize the results to other settings.

Hayden et al. (2008) used very similar processes that were considered for use at the project initiative site, aside from the printing location that was not listed as being at the bedside. Not printing the labels at the bedside made it harder to generalize the results to the project initiative location. According to Hayden et al., all specimens were collected by nurses, which could limit the ability to generalize the findings to the project site, as they also use nursing technicians and phlebotomists to collect specimens. Hayden et al. also noted that technology weaknesses such as scanner misreads should be identified and considered in advance of implementation to prevent workarounds. The project initiative therefore decided to test out the armband printers and wireless network connectivity sufficiently before implementation of new specimen collection technology. Hayden et al. reflected that data collection methods were a concern because the preimplementation data collection method was not defined in the study. The concern with data collection methods coincides with Brown et al.'s (2011) conclusion recommending that clear pre- and post-implementation data collection methods be outlined in advance of the change so that clear evaluation conclusions can be reached regarding study outcomes.

In a third study, by Hill et al. (2010), the authors confirmed that implementation of specimen collection technology had the ability to reduce mislabeled specimen rates when they noted a reduction from 0.42% to 0.11%. The retrospective study featured pre- and post-implementation data collection. In the Hill et al. study, there was no conceptual framework or theory referenced. The intervention studied by Hill et al. was an order-driven specimen collection system with barcode scanning and specimen labels printed at stations near the patient's room location in the Emergency Room but not directly at the bedside. Specimens were

collected by both nurses and technicians, which is similar to the proposed specimen collection process at the project site. Overall the Hill et al. study was rated at a level II strength for its quasi-experimental status and considered to be of good quality. Preimplementation data were collected for 44 months, and postimplementation data were collected for 17 months. The total study timeframe represents the longest study time frame of all articles critiqued.

Hill et al.'s (2010) study had some weaknesses. The lack of randomization could have an impact on the internal validity of the study. Hill et al. excluded blood bank and critical care-type patient specimens, making it difficult to understand the effect of the system for those specimen types. Hill et al. found that postimplementation, many errors continued to be present from manually labeled specimens. The continuation of manually labeled specimens suggests that the new specimen collection technology was not being used consistently, which could explain why Hill et al. did not see as significant a drop in mislabeling rates as others. The study did not feature bedside printing, with labels instead being printed to stationary printers just outside of patient rooms, potentially contributing to the ease in system workarounds. Finally, the study site experienced other concurrent patient safety initiatives while the study was going on, which might have influenced the study results (Hill et al., 2008).

As it translated to the project initiative site's proposed implementation, the lack of decentralized printing at the patient bedside could impact the ability to relate outcomes of the Hill et al. (2008) study to the actual outcomes at the project location. System workarounds attributed to a lack of bedside printing reinforced the need for bedside printers versus printing labels to a centralized location. Hill et al. (2010) noted that the system was not being used consistently, suggesting the need for continual auditing with timely feedback to users that could

help with system compliance. Furthermore, Hill et al. only collected data on specimens collected in the Emergency Room and did not include critical care and blood bank specimens, which could affect the ability to generalize the results to other areas, such as the maternal child health division at the project site.

The final article to address mislabeled specimen rates was carried out by Morrison et al. (2010). Study results indicated that mislabeled specimens decreased from 0.024% to 0.017% following implementation of automated specimen collection technology (Morrison et al., 2010). The results comparing mislabeled specimen rates pre- and post-implementation of specimen collection technology were found to be statistically significant with a *p* value equal to 0.0013. Other notable findings were that the system improved legibility of labels and did not slow collection times nor negatively affect the patient experience (Morrison et al., 2010). Morrison et al. used a nonequivalent control group, and data were collected before and after implementation for 10 months each. No conceptual framework was mentioned in the article. Morrison et al. implemented a mobile barcode scanning specimen collection system with wireless, bedside label printers. One difference recognized in Morrison et al.'s research was that only phlebotomist collections were evaluated and the study location did not use computerized provider order entry (CPOE).

Morrison et al. (2010) only focused on phlebotomist collections, which were found to have a lower error rate than other specimen collection roles in the facility. It was also mentioned that after implementation of specimen collection technology, less than 100% of the specimens were collected using the new technology (Morrison et al., 2010). The failure to use specimen

collection technology could indicate workarounds in the process that had the potential to impact the study results.

My project site uses CPOE, a safer version of order entry, which contributed to better improvements in their rates of mislabeled specimens as compared to Morrison et al.'s (2010) study. Morrison et al. also only used phlebotomists in specimen collection data, which is a smaller, more controlled group and may lead to challenges generalizing outcomes across sites. Involving clinicians in the process helps prevent the chance that workarounds will occur, as the needs of staff are considered in advance. Involving users in the design and implementation process was a recurring theme in the articles found and was the recommended process for the project site.

Collection Turnaround Time

High quality studies featuring collection turnaround time data were exceptionally difficult to find. One case study was identified by Behling, Marrone, Hunter, and Bierl (2015) and was considered of low strength and quality, yet was included in the literature review as it provides a baseline comparison of collection turnaround time data. Behling, et al. identified that collection turnaround times decreased by 13% due to the implementation of specimen collection technology.

One identified strength of Behling et al.'s (2015) study was that the postimplementation specimen collection workflow outlined in the study mirrors the proposed specimen collection workflow at the project initiative site. Additionally, Behling et al. focused on collection turnaround times, which was an outcome not mentioned in any other studies identified when

searching the literature. Results of Behling et al.'s case study were found to be statistically significant with a *p* value of less than 0.001.

A weakness of Behling et al.'s (2015) case study was that the study design was considered to be the lowest form of evidence and was not generalizable across settings. In light of the fact that the final identified specimen collection workflow in Behling et al.'s study was identical to the workflow at the project site and that it provided background collection turnaround time data, an outcome of interest in the project site's implementation, Behling et al.'s study was considered useful as a baseline reference point. Due to its low quality and strength, Behling et al.'s study could not be relied upon as the sole source of evidence and thereby was used with caution to inform practice.

General Literature

As implementing specimen collection technology is very specific to laboratory and nursing practice, there were no articles found outside of these practice realms for specimen collection technology. Sepulveda and Young (2013) did provide a thorough recommendation for laboratory information system functionality, with a specific section that focused on specimen collection. The Sepulveda and Young study featured a non-experimental research design based on subject matter questionnaires and interviews. As an expert review, it is considered of level IV strength but of good quality.

The Sepulveda and Young (2013) article recommended that specimen collection systems should offer the ability to scan patient wristbands to identify patients, unique collection lists per nurse or phlebotomist role, an online display of pending lab orders, and the ability to print lab labels at the patient bedside that contain regulatory-required lab data elements. Sepulveda and

Young also recommend specimen collection technology allows for data entry by specimen type, such as the entry of the collection site for blood culture specimens. Specimen collection systems were also suggested to be capable of supporting bidirectional interfaces with use of portable wireless scanning and printing devices, as well as allow for the specimen to be scanned upon receipt of specimen in the lab (Sepulveda & Yong, 2013).

An identified strength of the Sepulveda and Young (2013) article was that it provided a clear and specific review of desired specimen collection system functionality. The article also had some weaknesses that are important to note. The Sepulveda and Young article did not contain any information on the operational and technical details on how to implement the recommended functionality. The Sepulveda and Young article was weaker in strength because it relies on expert opinion through questionnaires, which could contribute to missing data in responses if questions were left unanswered. There could also be challenges with questionnaire data if subjects provided answers perceived as most acceptable versus an accurate representation of their experience. As there was no comparison group in the Sepulveda and Young article, there was an overall inability in drawing causal inferences from the report.

The Sepulveda and Young (2013) article was useful for the project initiative site's system planning purposes and also provided a helpful trend analysis. The list of desired specimen collection functionality was incorporated into workflow analysis discussions and decision making by the interdisciplinary project team. It was also helpful to include as a checklist during system testing to ensure the design decisions and actual workflows matched the recommended best system practices.

Theoretical and Conceptual Framework

The Agency for Healthcare Research and Quality (2007) recommended use of Donabedian's quality framework for healthcare implementations, indicating that evaluating the quality of health care can be drawn from the categories of structure, process, and outcomes. Structure is the environment in which care is provided. Process includes the interactions and activities undertaken in the delivery of care. Lastly, outcomes are the results of the healthcare processes on patients or populations. The Donabedian quality framework was flexible enough for application in a variety of settings in healthcare, and was pertinent in the evaluation of specimen collection technology across units in a hospital setting. See Figure 1 for translation of Donabedian's framework in reference to specimen collection technology.

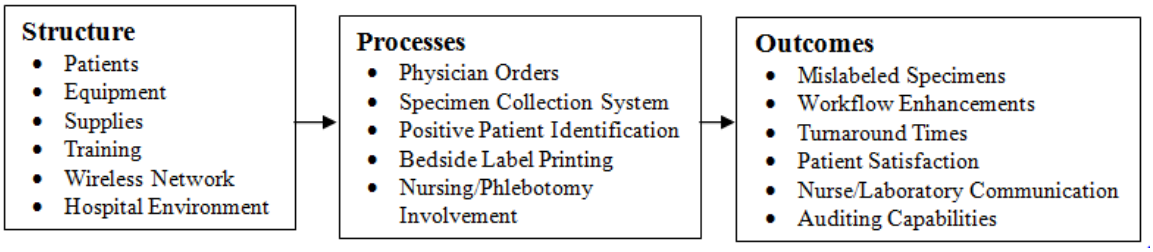

Figure 1. Donabedian's quality framework translated for specimen collection technology implementation.

In Donabedian's (1966) quality framework, the three boxes represent the three types of information that may be collected to draw inferences about the quality of care in a system. The first box represents structure, which includes all possible factors that affect the environment in which care is delivered (Donabedian, 1966). In the context of specimen collection, this includes available equipment like scanners and printers, the training provided to care givers, and the wireless network structure supporting use of the technology. The second box outlines the various processes that make up how the act of specimen collection is carried out (Donabedian, 1966). For specimen collection, this encompasses the ordering of laboratory tests and the steps taken

during specimen collection to identify the patient, obtain the specimen, label the specimen, print the labels for specimens, and scan the specimens. Finally, the outcomes box represents all the effects of specimen collection including mislabeled specimens, turnaround times, and patient satisfaction with specimen collection (Donabedian, 1966). It is through the monitoring of outcomes that one can measure the level of quality, which is impacted by structure and process. The goal of the specimen collection technology implementation was through the redesign of structure and process elements, the collection turnaround times and mislabeled specimen rates would be decreased.

Summary

In reviewing the literature, all studies showed a marked decrease in specimen mislabeled rates following implementation of technology regardless of area or specimen type. Some studies noted that lack of bedside printers and/or computerized provider order entry contributed to workarounds in the clinical environment that led to higher mislabeled rates, thereby recommending use of these technologies in conjunction with the implementation. (Hayden et al., 2008, Hill et al., 2010; Morrison et al., 2010). Though some studies initially excluded high risk specimens such as blood bank tests from collection with the new technology, they found the technology so reliable at reducing mislabeled specimens they eventually included these specimens during collection with the new technology (Brown et al., 2011; Hill et al., 2010), supporting including these types of high-risk, high-impact specimens as part of the initial implementation strategy. Additionally many of the studies struggled with inconsistent data collection and reporting mechanisms, which supports the recommendation of outlining a plan to address data collection prior to implementation so that the outcomes could be reliably measured

and compared pre- and post- implementation. Though the single case study available that discussed collection turnaround time was considered low quality, it was helpful to establish a point of reference for the project site implementation, which tracked turnaround time as one of their outcomes. The general literature suggests that specimen collection systems should show collection lists by role, display pending orders, support use of bidirectional interfaces, include scanning and bedside label printing capabilities, allow for data entry for certain specimen types, and allow for integration with the laboratory system and electronic health record. Other helpful hints gained from the literature review include involving end users in all stages of the project, the importance of testing the wireless network and barcode scanners prior to implementation to ensure they work appropriately, and the need for continuous auditing with timely feedback to staff to continually improve the usage of the technology. Utilizing the information gained from the literature helped ensure the project was successful and achieved the desired outcomes of interest.

Section 3: Collection and Analysis of Evidence

Introduction

The purpose of the specimen collection technology project was to evaluate the impact of the implementation of a positive patient identification and automated specimen collection system compared to the manual labeling of specimens with chart labels and paper requisitions on mislabeled specimens and collection turnaround times in the maternal child health department at a community teaching hospital. Available literature suggested a significant number of specimen collection errors could be prevented by the implementation of healthcare technology capable of positively identifying patients and specimens via bedside label printing and barcode scanning. There were many important components involved with planning and managing a specimen collection technology implementation, including accurate population identification, development of a project design and sampling methodology, the actual data collection, a plan for protecting human subjects, a strategy for data analysis with discussion of reliability and validity, and development of a detailed project evaluation plan. Developing a comprehensive plan to effectively incorporate these elements into program development increased the chances of the program being effective and staying on track in terms of data collection and outcome measurement. In Section 3, I discuss the project design and evaluation plan as part of the EBP implementation and evaluation of an automated specimen collection system with bedside label printing and scanning in the project site's maternal child health division.

Project Design and Methods

Mislabeled specimen rates and collection turnaround times in the maternal child health units were higher than desired benchmarks at the project initiative site. The existing manual

specimen label process was time consuming, inefficient, and error prone, leading the facility to question whether implementation of specimen collection technology could relieve these burdens. A project was proposed to implement Iatrics Mobilab specimen collection technology, allowing for patient wristband and laboratory specimen scanning to occur at the patient bedside. This allowed for the evaluation of the new technology compared to manual methods to determine if it was an effective strategy to reduce errors and improve the quality of specimen collection processes.

The project was a quantitative analysis with a pretest-posttest design. The dependent variables under investigation were mislabeled specimen rates per month and specimen collection turnaround times. Mislabeled specimens were recorded 6 months prior, the month during, and 6 months after the implementation of specimen collection technology and were used in conjunction with information regarding the total count of all specimens collected each month to generate monthly mislabeled specimen rates. A subset of monthly specimen collection turnaround time data was reviewed 3 months before, during, and after the implementation of specimen collection technology to identify and compare the number of specimens collected under 60 minutes or over 60 minutes. The mislabeled specimen rates and collection turnaround times were compared pre-, during, and post-technology implementation to determine the effect of the practice change on the prevention of errors and collection efficiency compared to manual specimen labeling processes using chart labels and paper requisition forms.

Population and Sampling

The group reviewed included specimens obtained from the adult/pediatric patient population admitted to the maternal child health division units at a community teaching hospital

3 to 6 months prior to Iatrics Mobilab implementation, the implementation month, and 6 months after. The laboratory information systems analyst identified all patients who had orders for the two most commonly ordered labs defined uniquely per area for labor and delivery, postpartum mother baby, newborn nursery, pediatrics, and NICU. These labs specifically were analyzed to determine collection turnaround time. Additionally, during the 19-month investigative window, data were collected and analyzed to determine the mislabeled specimen rate for the maternal child health units.

Data Collection

Prior to the collection of any project data, institutional review board approval was obtained from both the project site and Walden University. The Walden University institutional review board approval number for this project is 02-15-17-0514082. Each maternal child health unit had both mislabeled specimen data and collection turnaround time data analyzed based on implementation date. The preintervention data for mislabeled specimens was collected 6 months prior to the implementation, and collection turnaround times were collected for 3 months prior to implementation. Mislabeled specimen and collection turnaround time data collected in the month in which the Mobilab application was implemented was considered the intervention month, as some data were from the manual specimen collection process and some data were collected after using the new Mobilab specimen collection technology. There were 6 consecutive months of postimplementation mislabeled specimen and collection turnaround data collected representing the months when the Mobilab application was used exclusively for specimen collection.

Every mislabeled laboratory specimen was tracked and recorded by the project site's laboratory quality analyst to meet the College of American Pathologists' standard requiring

specimens to be uniquely identified to avoid errors. In order to generate a monthly mislabeled specimen rate, the monthly count of mislabeled specimens was divided by the total monthly count of all specimens collected in each area. The monthly mislabeled specimen rate was obtained from the laboratory for the 6 months preimplementation, the month of implementation, and the 6 months following the implementation of automated specimen collection technology.

Collection turnaround time was generated from a subset of all specimens collected in each unit of the maternal child health department. The top two most commonly ordered laboratory tests per unit were identified through the laboratory information system. During the third week of each month pre-, during, and post-implementation of the new specimen collection technology, each unit's most frequently ordered specimens were reviewed in the laboratory information system to determine the time the specimen was collected from the patient and the time the specimen was received in the lab. The difference between these values was indicative of the collection turnaround time. Each specimen collection was then categorized in one of the following collection turnaround time categories: under 60 minutes or greater than 60 minutes. The monthly collection turnaround time data were obtained from the laboratory for the 3months preimplementation, the month of implementation, and the 6months following implementation of automated specimen collection technology.

Instrumentation

Data collection form for recording collection turnaround times. The data collection tool was developed to capture the subset of lab specimen collection turnaround time data obtained from the laboratory information system (Appendix A). The tool was used to capture all specimen collection turnaround time data from the two most ordered tests for each maternal child health

unit for the entire third week of each month under review. Implementation in all maternal child health units occurred the second week of the month; therefore, the third week of each month was selected to gather a full week of data immediately following the implementation. As the data collection is a manual process and can be time consuming, 1 week of data was selected for collection each month as a sample for the units under review. The data collection tool assisted in defining if the specimen collection turnaround time could be categorized as under 60 minutes or over 60 minutes. The total of all categorized counts for the third week of each month was then investigated pre-, during, and post-implementation of automated specimen collection technology to determine if the new technology had a significant impact on collection turnaround times.

Data collection form for recording monthly mislabeled specimen rates. The data collection tool was developed to collect mislabeled specimen collection data (Appendix B). The tool captured the number of mislabeled specimens and total collected specimens from each maternal child health area each month pre-, during, and post-implementation of specimen collection technology. Each month, the count of mislabeled specimens divided by the total specimen count resulted in a mislabeled specimen rate. The mislabeled specimen rate was analyzed to determine the impact on the introduction of an automated specimen collection system on mislabeled specimen rate.

Protection of Human Subjects

The project initiative was approved by both the community teaching hospital and Walden University Institutional Review Board. No patient identifiers were obtained, and no data were shared without facility consent. Any published results of the project will not include identifying information. As the data being analyzed were not actual patient data, but specimen collection

system performance data, informed patient consent was not applicable to the project. The data are stored via a share drive on the secure network at the project site, protected behind the institution firewall and antivirus software and were accessed by institution computers that are password protected, encrypted, and housed on a locked unit of the facility.

Data Analysis

Data analysis using an independent samples *t* test compared the changes in the mean scores of the specimen collection turnaround times and mislabeled specimens pre- and post-implementation of specimen collection technology within each maternal child health unit location. All analysis was conducted using SPSS 17.0. Statistical significance (two tailed) was met with p values ≤ 0.05.

Reliability

Reliability is when a measurement tool consistently gives the same answer (Dearholt & Dang, 2012). As measuring and recoding collection turnaround time and mislabeled specimen counts per month was an objective measure, there is little chance the data collection tool could be used incorrectly. To account for any human error, there was one person overseeing all data collection and analysis. Specimen collection turnaround time data and mislabeled specimen data were collected the same way each month. The project involved a large amount of data collection, with numerous lab tests being captured and recorded for an entire week per month, which helped improve the reliability of the data.

Validity

Validity is whether the research measures what it intended to measure (Dearholt & Dang, 2012). Having the project goals and objectives clearly defined and operationalized helped

increase the project validity. The data collection tool gathered objective data that precisely matched the objectives that were being measured. I created the data collection tool, and it was reviewed by the specimen collection team and doctorate prepared preceptor to eliminate any confusing aspects of data collection. The measures defined for mislabeled specimen rates were defined at a national level by the College of American Pathologists.

Project Evaluation Plan

Evaluation Model

The model used by my facility to guide EBP projects was the Johns Hopkins nursing EBP model. The Johns Hopkins model was constructed based on three concepts that guide nursing: practice, education, and research (Johns Hopkins University, 2009). According to the Johns Hopkins EBP model, project evaluation should include both measurement and management of outcomes (Poe & White, 2010). The evaluation process was defined within the model as consisting of problem description, definition of outcomes, multidisciplinary team involvement, outcome measurement plan, data collection, data analysis and presentation, and translation of evidence and dissemination of findings (Poe & White, 2010). These elements were included in the evaluation plan for the project.

Performance Measurement, Monitoring, and Evaluation Timeline

Data collection and evaluation for the specimen collection technology project helped determine if the intended effects of the project were met. Each maternal child health division unit had both mislabeled specimen and collection turnaround time data analyzed monthly before, during, and after implementation. Preintervention data were collected 3 to 6 months prior to the implementation. Preimplementation data were necessary for determining a project baseline to

gauge implementation effectiveness. Data collected in the month in which the Mobilab application was implemented was considered the intervention month – as some data were from the manual specimen collection process and some used the Mobilab application. There were also be six consecutive months of postimplementation data collection representing the months when the Mobilab application was used exclusively for specimen collection. The evaluation of the data was completed over the span of 1 week to generate statistical evidence of the effect of the new specimen collection technology on mislabeled specimen rates and collection turnaround times, interpret the results, and produce a written evaluation summary for the project site.

The evaluation plan addresses the short term, immediate effects of implementation such as improved specimen collection efficiency and increased patient safety. Over time, not addressing specimen collection inefficiencies could increase patient length of stay and the chance that a catastrophic patient event could occur like an incorrectly matched blood transfusion or patient treatments based on erroneous lab values. The downstream effects of these events such as lawsuits and decreased community trust of the institution could be devastating.

Evaluation Plan

Per the Johns Hopkins nursing EBP model, strong evaluation includes defining the purpose of measurement, selection of clinical areas to evaluate, defining the indicators, developing design specifications for the measures, and the actual evaluation of the change (Deerholt & Dang, 2012). A specific and detailed evaluation plan was developed that includes outlined goals, objectives, and activities. The goal was to evaluate the specimen technology implementation in the maternal child health units at a community teaching hospital. The first measurable objective was that the mislabeled specimen rate would fall below the internal desired

best practice benchmark of 0.0100%. The second measurable objective was that 90% of all specimens would have a collection turnaround time of 60 minutes or less. There were nine primary activities that supported the goal and objectives, including multidisciplinary team development, metrics development, data collection, statistical evaluation, and the reporting and dissemination of outcomes. See Appendix C for a visual representation and comprehensive detail of the project evaluation plan. The evaluation data needed would include the monthly mislabeled specimen rate and collection turnaround time information.

Role of the DNP Student

I am employed as the nursing informatics manager at the practicum site. Part of my nursing informatics role is responsibility for the implementation of various clinical technologies in clinical practice. In my role of DNP student, I worked with the director of professional practice and was responsible for the development of data collection tools and the evaluation of the implementation of an automated specimen collection system, specifically the impact of technology on mislabeled specimen rates and specimen collection turnaround times.

The project site was a Magnet accredited community teaching hospital, with routine requirements for outcome data collection and evaluation. My personal motivations for this project included the demonstration of the value of nursing informatics specialists as part of the project team structure, the demonstration of the impact that technology can bring to patient related outcomes in healthcare, and the desire to learn and follow the institutional methodology for implementation of evidence-based projects. As my role as an informatics nurse focused on the implementation of technology in the hospital setting, I was aware of my personal bias towards the implementation of technology as the best solution for positively impacting clinical

practice. Keeping an objective mindset and using statistical analysis software helped me overcome these personal biases.

Summary

An important part of the project implementation process was delineating the project design and methods, population and sampling, data collection, data analysis, and evaluation plan. The process of detailing the project components was important, because if insufficient attention was paid to how the project was structured and how data was collected, the outcome would be reliable and therefore could not be generalized to a larger population (Winsett & Cashion, 2007). The community teaching hospital specimen collection technology implementation involved quantitative data collection with a pretest-posttest design. Data on specimen collection turnaround time rates was collected on each maternal child health unit for three months before, the month during, and six months following the implementation of specimen collection technology, while monthly mislabeled specimen data was collected for six months before, the month during, and six months following the implementation The data was then statistically analyzed by the DNP student and related to the goals and objectives of the project, as outlined in the evaluation plan, producing a tangible deliverable explaining the impact of the specimen collection technology project for the organization.

Section 4: Findings and Recommendations

Introduction

The maternal child health units at the project site were experiencing unacceptable mislabeled specimen rates and increased specimen collection turnaround times. Though many initiatives such as bedside labeling and attempts to control for mislabeled specimens can have an impact on the specimen collection process, these initiatives had only slight measurable and sustainable effects on error rates. The purpose of the specimen collection technology project was to evaluate the impact of the implementation of a positive patient identification and automated specimen collection system as compared to manual labeling of specimens with chart labels and paper requisitions on mislabeled specimens and collection turnaround times in the maternal child health department at a community teaching hospital. Data related to collection turnaround time and mislabeled specimens were obtained with laboratory quality analyst assistance from the laboratory information system. In Section 4, I discuss a summary of findings as related to project objectives and compared to the literature, policy, practice, research and social change implications, project strengths and limitations, and a self analysis.

Summary of Findings

There were two objectives that addressed the practice-focused question: How does implementation of a positive patient identification /automated specimen collection system as compared to manual labeling of specimens with chart labels and paper requisitions affect the mislabeled specimen rate and collection turnaround times in the maternal child health units at a community teaching hospital?

Mislabeled Specimens

The first objective was that immediately following the implementation of specimen collection technology, the mislabeled specimen rate would fall below the internally developed laboratory best practice benchmark of 0.0100% as measured by laboratory quality data. Mislabeled specimen percentages in all areas decreased from an average of 0.0250% preimplementation to an average of 0.0023% postimplementation with a $p < 0.001$. Alternatively stated, the mislabeled specimen count decreased from an average of two per month total in all areas preimplementation to an average of zero per month total in all areas postimplementation. See Figure 2 for graphical interpretation of the results and Table 1 for numerical interpretation of the results.

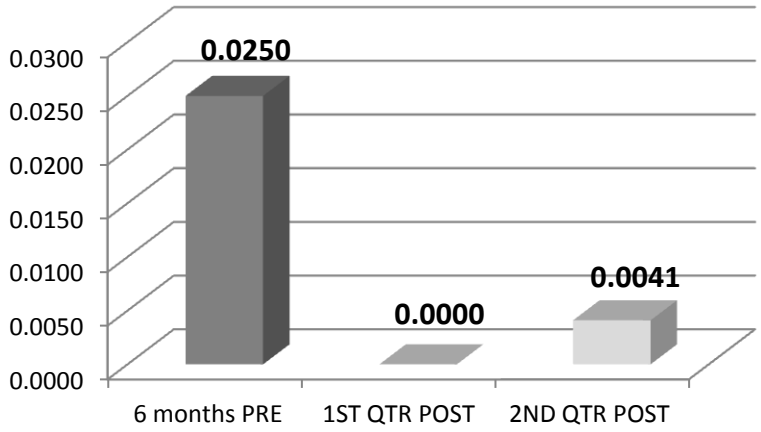

Figure 2. Average percentage of mislabeled specimens pre- and post-implementation of specimen collection technology in maternal child health units at a community teaching hospital.

Table 1

Mislabeled Specimen Counts and Percentages Pre- and Post-Implementation of Specimen Collection Technology

	6 months PRE	1st QTR post	2nd QTR post	6 month post total	
Total mislabeled count	4	0	0	0	
Total unlabeled count	7	0	1	1	
Total both count	11	0	1	1	
Total number of specimens collected	44052	19477	24258	43735	
					p value
Total mislabeled %	0.0091%	0.0000%	0.0000%	0.0000%	< 0.001
Total unlabeled %	0.0159%	0.0000%	0.0041%	0.0023%	< 0.001
Total both %	0.0250%	0.0000%	0.0041%	0.0023%	< 0.001

Collection Turnaround Time

The second project objective was that following specimen collection technology implementation in the maternal child health division, 90% of all specimens would have a collection turnaround time of less than or equal to 60 minutes as measured by laboratory collection statistics. Collection turnaround times greater than 60 minutes decreased following the implementation of specimen collection technology by an average of 22% ($p < 0.001$). Each unit as well as the total unit average of collection turnaround times decreased to fewer than 5% of samples greater than 60 minutes from average preimplementation scores of 25%. See Figure 3 for a graphical representation of the results and Table 2 for a numerical representation of the results.

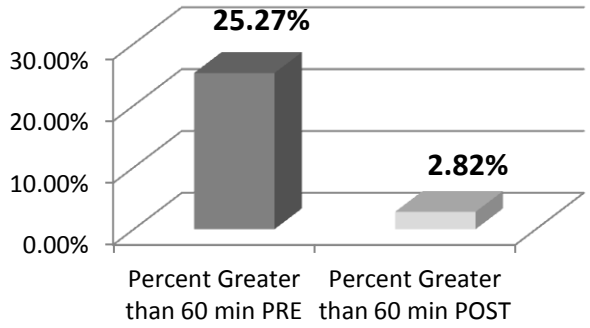

Figure 3. Average percentage of collection turnaround times greater than 60 minutes pre- and post-implementation of specimen collection technology in maternal child health units

Table 2

Unit Based and Total Percentages of Collection Turnaround Times Pre- and Post-Implementation of Specimen Collection Technology

	Percent greater than 60 min PRE	**Percent greater than 60 min POST**	**P-value Chi Square test of significance**
Labor and Delivery	32.23%	4.08%	$p < 0.0001$
NICU	35.42%	4.67%	$p < 0.0001$
Postpartum Mother Baby	18.64%	0.00%	$p < 0.0001$
Nursery	21.88%	1.66%	$p < 0.0001$
Pediatrics	18.18%	3.70%	$p = 0.122$ *sample size too small*
TOTAL	**25.27%**	**2.82%**	***p* < 0.0001**

Discussion of Findings in Context of Literature

Following the implementation of specimen collection technology, both mislabeled specimen percentages and collection turnaround times were significantly decreased. Of interest to note is that the average mislabeled specimen percentage following implementation of 0.0023% was less than the best reported postimplementation rate from the literature of 0.0050% (Hayden et al., 2008). Collection turnaround times were also much better than the reported figures in literature, with collection times reduced by an average of 22% following implementation, compared to the best reported postimplementation decrease in the literature of 13% (Behling et al., 2015).

Though not included in the outcomes that were measured as part of this project improvement initiative, several other benefits were realized by implementing specimen collection technology. One benefit was improved communication between nursing and laboratory staff. Improved communication was due to new reports that were available in the system to track if the specimen had already been collected or was still due to be collected. The system also contained netting technology that launched when a patient wristband was scanned identifying specimens ordered to be collected by other clinician types within a 4-hour window, decreasing the number of sticks the patient potentially had to experience and helping to reduce the number of missed collections. Another realized benefit was increased compliance with required elements on the specimen label, since anything entered in the system would automatically print on the collection labels. Lastly, there was the benefit of the increased ability to track and monitor the specimen collection process and identify exactly what was occurring at the bedside through audits.

Implications

Policy

The United States is undergoing massive revisions to the existing healthcare system in an effort to increase the quality, safety, and access to healthcare. Appropriate use of information technology can transform healthcare through improved outcomes and reduced costs of care. The relevant literature has indicated that a significant number of specimen collection errors can be prevented by the implementation of specimen collection technology. The Center for Disease Control and Prevention (CDC; 2016) has gone as far as to recommend the use of electronic point of care and barcode specimen collection systems to prevent specimen and laboratory testing identification errors. The specimen collection technology project supports that recommendation and also illustrates that collection turnaround times can be dramatically reduced following the implementation of specimen collection technology. There is no current legislation at the state or national level surrounding the implementation of specimen collection technology. Support of the CDC recommendation to implement collection technology can be communicated to legislators and regulatory agencies involved in making health care policy decisions in the hopes that it becomes part of the minimum standard in regulations and policy documents such as the Joint Commission National Patient Safety Goals and Government Meaningful Use Standards. The support of the specimen collection technology project for the CDC recommendation therefore has the potential to significantly impact the quality and safety of patient care across the healthcare continuum, benefitting the healthcare consumer economically and physically.

Practice

The findings of this EBP project are consistent with the studies in the literature. There is strong support that implementation of specimen collection systems has a significant impact on reducing mislabeled specimens and improving the overall efficiency of specimen collection, reducing collection turnaround times. Improving specimen collection outcomes can substantially benefit patients through increased diagnostic accuracy, decreased chance of patient injury, decreased length of stay, decreased healthcare costs, and increased patient satisfaction. Knowing this, the implementation of specimen collection systems should continue to be the recommendation to improve nursing practice.

Research

The specimen collection technology project supports the existing body of research that specimen collection technology paired with computerized physician order entry and positive patient identification with scanning reduces mislabeled specimens. It also contributes new knowledge toward the collective of information about how technology plays a role in improving collection turnaround times. The project presents future opportunities of study to investigate the reasons why clinicians choose to circumvent the use of technology in the clinical setting. When specimen collection technology is used, there is essentially no chance that a specimen could be sent mislabeled to the lab. Despite this, following the implementation of the technology, the lab continues to occasionally receive mislabeled specimens from clinical staff. A more detailed understanding of the circumstances that contribute to not using the required technology would benefit continued improvements in the specimen collection process.

Social Change

The body of evidence supporting specimen collection technology implementation across clinical practice paves the way for improved large scale decisions supporting or requiring this technology in practice. It is through diligent and persistent design, support, and analysis of specimen collection technology implementations that allow us to better understand the impact to clinical practice. The specimen collection technology project showed profound improvement of outcomes and reduction of potential collection and diagnostic errors that played a role in improving the lives of patients, their families, and communities. The knowledge of the benefits of implementing specimen collection technology can continue to be applied in other settings to spread the impact of this change to a larger audience.

Prior to implementing specimen collection technology, workflows were inefficient, complex, and often frustrating to clinical staff. Following the implementation of collection technology, clinical staff reported an increased satisfaction with the collection process and take pride that the quality of the collection process has improved, citing the benefits to patients through the change process. The relationships between the laboratory, phlebotomy, nursing, and patient care technician groups have also improved, as there is less confusion about who is responsible for various collection responsibilities, and communication is enhanced by the easy access to information saved in the system. Improved collection turnaround times have also helped to drive faster lab results for patients, which the physician team has expressed as being a positive impact of the implementation.

Project Strengths and Limitations

Strengths

There were many project strengths that contributed to the successful implementation of specimen collection technology in a Baltimore community hospital. The first was the formation of a strong, interprofessional collaborative that was committed to improving patient outcomes related to specimen collection. The dedication of the project team drove careful consideration of all project decisions, which allowed for the best possible outcomes to transpire.

Another important strength was the backing and commitment from the leadership teams at the hospital. Information technology leadership dedicated resources and ongoing support to the project. Executive support provided the funding for the project, while laboratory and nursing leadership support paved the way for staff to be involved in the project, all staff were required to attend training, and unit dollars were allocated for implementation support.

Another vital strength in this project, similar to all technology implementations, was the involvement of clinical end users throughout the entire project process. Each unit in the department was represented so that workflows could be thoughtfully discussed and decided prior to training and implementation. The involvement of all units in clinical decision making helped uncover potential risks and challenges that could be resolved and incorporated into the training and support plan. Involving end users also benefitted the units in allocating a dedicated unit based expert for training, implementation, and ongoing unit support.

The development of a comprehensive training program also acted as a project strength. The training plan was developed by the project team with content detailing the new hardware, how provider orders flow into the system from order entry, how to log in, user configuration of

the device including unit selection and printer selection, correctly identifying patients, labeling of specimen containers, performing a normal collection, entering a not-drawn reason, the blood bank process, entry of specimen source for microbiology specimens, entering collection comments, printing of demographic labels, and how to add on laboratory tests using the application. Training was required by all staff responsible for collecting specimens. Informatics nurses were responsible for training the nurses and techs collecting specimens, while the laboratory trained their staff on a new electronic tracking board, the patient list view, and how to process add on requests. Super users for each area attended multiple classes to gain confidence in preparation for implementation. Training began 2 weeks prior to implementation and classes were 2 hours in duration. They featured a didactic component with hands on application and an independent competency where users walked through five different scenarios using the new technology. The training program with competency assessment allowed the informatics nursing team to feel confident that staff had a strong understanding of the new technology prior to implementation.

Finally, the ability of the project team to continuously audit the new specimen collection processes via technology and provide real time feedback to staff was a great benefit to the implementation. Audits helped capture any system usage fallouts as well as who was performing tasks incorrectly. The team followed up with users individually to provide on-the-spot learning and reinforcement of correct processes. Following implementation, reports continue to be used monthly to track and record any usage errors.

Limitations

Despite the best planning and intentions, technology implementations can be unpredictable. It is impossible to control everything that occurs clinically during technology implementations, particularly the human interaction element. Users may be frustrated by the change, forget components of training, or feel unsure of what to do in all circumstances. Though markedly decreased, there continued to be mislabeled and unlabeled specimens sent to the lab after implementation. Though not included in the outcomes measured for this project, there continue to be other system errors as well. These include not scanning the specimen as the final part of the collection process, forgetting to enter the site for blood cultures, and any of the steps required for collection a blood bank specimen. Additional investigation is required to understand the nature of why these errors continue to occur.

Recommendations for Remediation of Limitations in Future Work

A future focus on the types and causes of continued system errors would benefit the understanding of the best way to prevent errors in the future. A greater understanding of the factors that contribute to less than 100% adherence to system operating procedures could lead to changes in system configuration, training, support, and accountability structures required in driving continuous improvements in the new specimen collection system. Possible ways to achieve greater improvements in the specimen collection process post-implementation include initiating quality audits where collections are being observed real time on the units and mandatory refresher training classes for those with continued system errors.

Self Analysis

As Scholar

The Doctorate of Nursing Practice graduate is expected to demonstrate practice expertise, specialized knowledge, and expanded accountability and responsibility in providing care to patients and communities (AACN, 2006). Throughout this project experience, I have gained a vast amount of knowledge and experience in the use of an evidence-based model, working as part of an interdisciplinary team, the development of a practice question, acting as a project leader and agent of change, conducting an evidence search, appraising evidence, developing evidence-based recommendations for change, creating a project action plan, implementing and supporting a project, evaluating project outcomes, and sharing the information gained internally and externally. The growth of my knowledge base will allow me to act as a mentor to others undertaking projects on my team and in my workplace. I have also become versed on specimen collection systems, challenges, benefits, implementation, and evaluation strategies that will allow me to act as a resource for others undergoing similar implementations.

As Practitioner

Throughout my doctorate experiences, I have had the ability to conduct an assessment of a current health issue or problem, design a comprehensive approach to improving the outcomes associated with the issue, work collaboratively with other healthcare professionals, translate research into appropriate clinical actions that improve patient outcomes, mentor other nurses in the improvement of nursing care, support a team through a complex health problem, and develop skills to evaluate the overlapping areas of practice, organizations, populations, financial, and policy. These aforementioned elements are required of the doctoral nurse in day to day practice

to ensure the ability to advance the nursing profession as a whole. I feel I have grown in my confidence and ability to lead and drive increased reliance on EBP in healthcare, and have developed competence in the use of several EBP tools as part of the Johns Hopkins nursing EBP model.

As Project Developer

My practicum experience provided valuable education and opportunities to witness a number of project implementations, various opportunities to assess my own implementation experience and awareness, and the ability to address change management from a system wide perspective. I was able to lead a successful EBP project as part of a developed interprofessional team that significantly improved outcomes at the practicum site. I feel confident in my personal ability to manage and evaluate technology implementations, as well as work collaboratively with others to achieve project goals aligned with the vision and strategic plan of the facility. Initially in my practicum experience I was more focused on the role of informatics in the deployment of technology, but have grown to see technology implementations as being intertwined with practice in the complex environment of healthcare delivery.

What Project Means for Future Professional Development

The ability to design, manage, implement, and evaluate a technology project of this magnitude has also enabled me to advance my skills in leadership and knowledge dissemination. The expansion of my knowledge of the EBP process was an area I was seeking to develop through this program. The evaluation and contribution towards a manuscript for potential publication has provided valuable experience and allowed me the opportunity to feel confident in submitting manuscripts for future publications and abstracts for potential speaking engagements.

Completing this project is also a critical step in obtaining my doctorate degree, which will allow me better opportunities to educate students at a collegiate level to share my knowledge with future generations of nurses.

Summary and Conclusions

Implementing a specimen collection system that fostered positive patient identification with bedside labeling and scanning significantly reduced the mislabeled specimen rate in maternal child health units from 0.0250% pre-implementation to 0.0023% post-implementation. Reducing the mislabeled specimen rate is critical, as mislabeled specimens contribute to misdiagnosis, incompatible blood transfusions, delayed treatment or treatment decisions based on incorrect information, and decreased patient satisfaction. Specimen collection technology also streamlined the specimen collection process, reducing collection turnaround time by 22%. Reducing collection turnaround time is significant, as faster access to lab results reduces healthcare costs and improves the quality of care provided to patients through removing process inefficiencies that contribute to errors. Overall, implementation of specimen collection technology paired with computerized provider order entry, barcode scanning, and bedside label printing was found to be a viable strategy capable of significantly reducing specimen collection errors and improving the efficiency of the collection process.

Section 5: Scholarly Product

Dissemination Plan

The dissemination of project findings to clinicians is critical in EBP projects. Findings generated from nursing projects and studies help guide the development of new clinical practices and verify existing approaches (Oermann, Shaw-Kokot, Knafl, & Dowell, 2010). The information gained from the project will be disseminated in three ways. The first method is through internal presentation of the findings to nursing and laboratory leadership. The benefit of internal dissemination is that the project stakeholders will be updated on the outcomes of the project.

The second method of dissemination is through a podium presentation at a national conference. An abstract was submitted to the American Medical Informatics Association (AMIA) on March 8, 2017 for their annual conference. Presenting at a conference will allow for contributing to knowledge in the informatics field, advocating for specimen collection technology, and broadening my personal knowledge base. Notification regarding status of abstract submission will be provided by AMIA in June.

The last method of dissemination is submission of a research manuscript to the Journal of the American Medical Informatics Association. I wrote the manuscript with contributions from the project site biostatistician and director of professional practice. Articles published in academic journals provide access to the widest audience allowing for the greatest transfer of information. The manuscript, submitted on March 14th, is outlined in this section and is considered the primary scholarly product from the practicum experience.

Effectiveness of Automated Specimen Collection Technology in the Reduction of Collection Turnaround Time and Mislabeled Specimens in Emergency, Medical Surgical, Critical Care, and Maternal Child Health Departments

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Keywords: Bar Coding, Health Care Errors – Prevention and Control, Patient Identification, Specimen Handling, Systems Implementation

Word Count: 3748

Abstract

Objective: To evaluate the impact of specimen collection technology implementation featuring computerized provider order entry, positive patient identification, bedside specimen label printing, and bar code scanning on reduction of mislabeled specimens and collection turnaround times in the Emergency, Medical Surgical, Critical Care, and maternal child health departments at a community teaching hospital.

Methods: Quantitative analysis with a pretest-posttest design evaluated statistical significance of reduction of mislabeled specimen percentages and collection turnaround times impacted by implementation of specimen collection technology.

Results: Mislabeled specimen percentages in all areas decreased from an average of 0.020% pre-implementation to an average of 0.003% post-implementation with a *p* value less than 0.001. Collection turnaround times greater than sixty minutes decreased following implementation of specimen collection technology by an average of 27% with a *p* value less than 0.001.

Discussion: Specimen collection and identification errors are a significant problem in healthcare, contributing to incorrect diagnoses, delayed care, lack of essential treatments, and patient injury or death. Collection errors can also contribute to increased length of stay, increased healthcare costs, and decreased patient satisfaction. Specimen collection technology, when utilized as intended, has structures in place to prevent patient identification errors and improve the overall efficiency of the specimen collection process.

Conclusion: Specimen collection technology has the ability to drive safety process improvements by reducing errors caused by mislabeled specimens and improving collection turnaround times.

INTRODUCTION

There has been a recent focus in healthcare on the prevention of medical errors that have a significant impact on patient outcomes. According to the Institute of Medicine[1], technology plays a pivotal role in creating systems that are inherently proficient at reducing preventable errors. The literature indicates that specimen identification error rates in systems that do not utilize technology range from 0.024% to 0.420%[2, 3] which constitutes a serious problem, as errors contribute to incorrect or delayed treatment. Specimen collection and identification errors may cause significant patient injury or disability, increased lengths of stay, increased healthcare costs, diverted resources, and decreased patient satisfaction[4]. Valenstein, Raab, and Walsh estimated that over 160,000 adverse medical events each year can be attributed to misidentification of laboratory (lab) specimens[5].

Accurate specimen labeling is critical to prevent patient harm and increased costs of care[6]. Although initially launched in 2003, the Joint Commission continues to list accuracy of patient identification as a National Patient Safety Goal, requiring two patient identifiers at the point of care and recommend that specimens be labeled in the presence of the patient[7]. The importance of ensuring correct patient and sample identification is also reinforced by the College of American Pathologists[8]. The Centers for Disease Control and Prevention have additionally endorsed the use of electronic point of care and barcode specimen collection systems to prevent specimen and laboratory testing identification errors[9].

When searching for literature, articles related to specimen collection systems were challenging to find. Articles reviewed matched the intervention strategy considered by Mercy Medical Center, including implementation of a computerized provider order entry (CPOE)

driven specimen collection system featuring positive patient identification and specimen label printing. Equally important was having the labels print in or close to the patient room where the patient's wristband and lab labels were scanned with barcode reader technology. In the literature, mislabeled specimen rates prior to implementation of specimen collection technology ranged from 0.024% to 0.420%[2, 3]. Following implementation of specimen collection technology, the mislabeled specimen rates dropped to 0.005% to 0.110% [3, 10]. One case study was identified showing a decrease in collection turnaround times by 13% following implementation of specimen collection technology[11]. Overall, the articles suggest that specimen collection and scanning technology paired with bedside label printing is a valid intervention to consider for improving the overall quality and safety of the specimen collection process.

BACKGROUND AND SIGNIFICANCE

Mercy Medical Center, a 280-bed community teaching hospital in Baltimore, MD, features four Centers of Excellence including the Institute of Cancer Care, the Institute for Digestive Health and Liver Disease, the Orthopedic Specialty Hospital, and the Center for Women's Health and Medicine. The hospital admits approximately 16,000 patients per year, and performs over 28,000 surgeries annually[12]. Mercy Medical Center is also a Magnet recognized organization, bestowed by the American Nurses Credentialing Center as one of the top hospitals nationwide for quality patient care and nursing excellence[13].

Mercy Medical Center's original specimen collection practice involved utilizing patient chart labels and printed lab requisition forms from the order entry system in the electronic health record. As part of the specimen collection process, the nurse or tech would verbally verify the patient's identity and compare the information to the paper requisition form to confirm the

identity of the patient and the specimens that needed to be collected. Following collection, the nurse or tech would apply generic patient chart labels to the specimen containers at the bedside. The person collecting specimens had to remember which specimen container types to use for each specimen ordered and when to write certain information on the patient chart labels used on the specimen containers, such as the site of a blood culture draw to assist in researching suspected sepsis cases. Blood bank specimens were even more involved, requiring two nurses at the bedside reviewing and labeling a special blood bank requisition and blood bank patient wristband. Locating a second nurse for blood bank test verification and to observe the collection could prove time consuming for clinical staff. Following collection, specimen containers were sent to the lab in a biohazard bag with the requisition form, where the laboratory technicians would take additional time to re-enter the specimen(s) into the lab information system. After marking the specimens as received into the system, a bar code label was generated and placed on the specimen that could be utilized by the laboratory analyzing equipment. If the original specimen collection process was not followed specifically with these multiple steps, an error could easily occur.

Patient care is dynamic, often requiring staff to complete activities quickly and under pressure, increasing the chance of mistakes occurring. Mercy Medical Center's manual specimen collection process was time consuming and inefficient at times, which could contribute to clinical staff considering system workarounds to complete activities faster. Using the original, manual specimen collection procedures, an average of thirty percent of all specimens from the Emergency, Medical Surgical, Critical Care, and maternal child health departments took greater

than one hour to process from collection time to the point where the specimen was received in the laboratory.

When best-practice procedures are followed in the laboratory specimen collection process, the chance of mislabeling a tube is close to zero[14]. Despite having defined best-practice safety measures in place such as utilizing two patient identifiers, the use of pre-printed patient chart labels applied at the bedside, the reliance on a comprehensive specimen collection training program, and defined specimen collection policies, there continued to be a 0.020% mislabeled/unlabeled specimen rate. This rate was greater than the internally developed laboratory suggested best practice benchmark of less than 0.010%. There were concerns that the existing specimen collection process had the potential for workarounds and could contribute to errors in labeling specimen containers.

In contrast, when utilizing the Iatrics Mobilab specimen collection system, the software is launched and the account number on the patient wristband is scanned with a barcode scanner to initiate the process. The scanner can be connected to a desktop or laptop computer, or in the case of this study, integrated within a personal digital assistant device connected to the wireless network. Once the patient identification is verified by the nurse or tech, the system displays the lab tests ordered for the patient in the order of collection and prints the specimen labels at the bedside on a wireless label printer. The bulk of the specimen orders entered in the system are placed via CPOE. Specimen labels contain the following information: barcode linked to the accession number generated from the provider order, accession number, patient name, patient sex, patient birth date, account number, medical record number, unit where patient is located, name of laboratory test ordered, name of specimen container required for collection, date/time of

collection, and collector's mnemonic. Without positive patient identification, there is no way to force the specimen labels to print. Once specimen labels print, they are immediately applied to the specimen containers at the patient bedside and scanned to indicate they are in a collected status. The specimens are then sent to the laboratory for processing, where they are scanned in by the laboratory technician and then routed to the correct lab location for processing. The safety mechanisms built into the system are what drive the accurate identification and specimen labeling practice. During the implementation phase, the nursing and technician staff members responsible for collecting specimens were educated that the only time it would be permissible to send a specimen to the lab without using the new specimen collection technology was during a system downtime or patient code situation where timing was considered critical.

Utilizing the new Iatrics Mobilab specimen collection system, each exact step in the process is tagged with a time stamp in the system which is attached to a unique clinician login, which makes it easier to identify if a user is not following the recommended collection procedures and where the errors are occurring in the process. The ease of having all specimen information at the clinician's fingertips, along with container types and the order of collection specified saved clinical staff time and effort. The safety checks in the system also allow for a change in blood bank specimen collection policy, no longer requiring a second nurse in the room at time of collection to verify the process. The ability to demand-print barcode specimen labels at the bedside as part of the process also means there is less time spent looking for patient chart labels and paper order requisitions, and less time for the lab in relabeling specimens. All of these features together have the capability of maximizing efficiencies and reducing the time spent in the collection process.

THEORETICAL UNDERPINNINGS

The Agency for Healthcare Research and Quality[15] recommended use of Donabedian's Quality Framework for healthcare implementations, indicating that evaluating the quality of health care can be drawn from the categories of structure, process, and outcomes. Structure is the environment in which care is provided. Process includes the interactions and activities undertaken in the delivery of care. Lastly, outcomes are the results of the healthcare processes on patients or populations. The Donabedian Quality Framework is flexible enough for application in a variety of settings in healthcare, and is pertinent in the evaluation of specimen collection technology across units in a hospital setting. See Figure 1 for translation of Donabedian's Framework in reference to specimen collection technology. The three boxes represent the three types of information that may be collected to draw inferences about the quality of care in a system. It is through the monitoring of outcomes that one can measure the level of quality, which is impacted by structure and process[16].

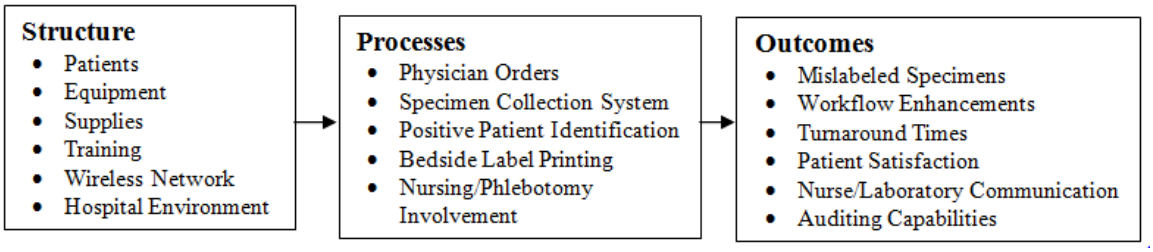

Figure 1. Donabedian's Quality Framework translated for specimen collection technology implementation

OBJECTIVE

The research question for the study was: In patients located in a community teaching hospital, how does implementation of specimen collection technology compared with manual labeling of specimens with chart labels and paper requisitions affect mislabeled specimen rates and collection turnaround times? The hypothesis was there would be a statistically significant

decrease in mislabeled specimen rates and collection turnaround times across the combined units. There were also two study objectives. The first objective was that immediately following the implementation of specimen collection technology across the identified departments, the mislabeled specimen rate would fall below the internally developed laboratory best practice benchmark of 0.010% as measured by laboratory quality data. The second objective was that within the first month following specimen collection technology implementation across the defined divisions, ninety percent of all specimens would have a collection turnaround time of less than or equal to sixty minutes as measured by laboratory specimen collection data.

METHODS

Implementation Plan

The implementation of specimen collection technology occurred sequentially across four distinct phases in the emergency, maternal child health, medical surgical, and critical care departments. The primary reasons for phasing the implementations was so that the necessary time and discussions needed for thorough workflow analysis could be devoted to each area, to allow for customization of department specific training and support materials, and to promote robust implementation support to each unit. Prior to initiating the project, the objectives and data collection needs were defined.

Workflow analysis and application development began three months prior to implementation and included nursing informatics, project management, laboratory systems analysts, clinical nurses, nursing leadership, clinical educators, systems analysts, and help desk staff. During this time, there were weekly team meetings focused on large scale decisions and project progression, and separate department-specific meetings with clinical staff, leadership,

and educators to discuss workflow and application decisions. Technology demonstrations were held, existing and future-state process flows were mapped out, policies were updated, and all practice, hardware, and application decisions were made.

One month prior to implementation of the new technology, the application and hardware was configured and tested by clinical users in the test environment. A comprehensive training plan was developed by the project team with content detailing the new hardware, how provider orders flow into the system from CPOE, how to log in, and user configuration of the device including unit and printer selection. Collection process education included correctly identifying patients, labeling of specimen containers, performing a normal collection, entering a not-drawn reason, the blood bank process, and entering the specimen source for microbiology specimens. Additional functionality was also covered in training including entering collection comments, printing of demographic labels, and how to add on laboratory tests using the application. Training was required by all staff responsible for collecting specimens. Informatics nurses were responsible for training the nurses and techs collecting specimens, while the laboratory trained their staff on a new electronic tracking board, the patient list view, and how to process add on requests.

Training began two weeks prior to implementation and classes were two hours in duration. They featured a didactic component with hands on application and an independent competency where users walked through five different scenarios using the new technology. Super users for each area attended multiple classes to gain confidence in preparation for implementation.

Implementation support was provided by the project team and the super user team for three full days. Super users acted as unit resources, and the project team hosted a command center with a dedicated phone line for issue escalation. After the first three days, implementation support was provided by the project team for an additional seven days. Ongoing audits during implementation identified incorrect processes and allowed for timely feedback to users. Following implementation, reports were used to track and record any usage errors. Fall outs were reported back to users with additional education.

Design

The study was a quantitative analysis with a pretest-posttest design. The dependent variables under investigation were monthly mislabeled specimen rates and specimen collection turnaround times. Mislabeled Specimens are defined as specimens that are collected from one patient but are labeled with another patient's name or unlabeled specimens that are lacking a specimen label entirely. Collection turnaround time is defined as the time the specimen is collected from the patient through the time the specimen is received in the lab.

Population and Sampling

The sample includes the specimens obtained from the patient population located in the emergency, medical surgical, critical care, and maternal child health department units at Mercy Medical Center three to six months prior to Iatrics Mobilab implementation, the implementation month, and twelve months after. The medical surgical department consists of two telemetry units, a gynecology and spine unit, an oncology unit, and an orthopedic unit. The critical care department includes critical and intermediate level care patients. The maternal child health

division includes labor and delivery/nursery, postpartum mother-baby, a neonatal intensive care unit, and pediatric units.

Data Collection Methods

Prior to the collection of any data, the study was submitted to Mercy Medical Center's Institutional Review Board, and was deemed to be exempt from oversight. No patient identifiers were obtained or utilized during data collection. As the data being analyzed was not actual patient data but specimen collection system performance data, informed patient consent was not applicable to the project.

Every mislabeled laboratory specimen from units included in this study was tracked and recorded by Mercy Medical Center's laboratory quality analyst to meet the College of American Pathologists' standard requiring specimens to be uniquely identified to avoid errors[17]. In order to generate a monthly mislabeled specimen rate, the count of mislabeled specimens each month was divided by the total count of all specimens collected per month. The monthly mislabeled specimen rate was obtained from the laboratory for the six months pre-implementation, the month of implementation (including two weeks of data from the manual specimen collection process and two weeks of data following implementation of the new technology), and the twelve months following implementation of automated specimen collection technology. A data collection tool was developed to collect mislabeled specimen collection data (Appendix A).

Collection turnaround time was generated from a subset of all specimens collected in each unit included in the study. The top two most commonly ordered laboratory tests per unit were identified through the laboratory information system. As the data collection is a manual process and can be time consuming, one week of data was selected for collection each month to

serve as a sample for the units under review. During the data collection window, each unit's most frequently ordered specimens were reviewed in the laboratory information system to determine the difference in time between when the specimen was collected from the patient and the time the specimen was received in the lab. Each collection turnaround time was classified as less than or greater than sixty minutes. The subset of collection turnaround time data was obtained for three months before, the month during, and twelve months following implementation. A data collection tool was developed to capture the subset of lab specimen collection turnaround time data obtained from the laboratory information system (Appendix B).

Data Analysis

Proportions (percentages) for both the mislabeled specimens as well as the turnaround times were compared between pre and post intervention using Chi-square tests of 2x2 contingency tables. Each of these tests was done by unit location as well as the combined unit location total. All analyses were conducted with STATA 12. P-values are reported in tables and statistical significance is considered $p \leq 0.05$.

QUANTITATIVE RESULTS

Mislabeled Specimens

Mislabeled specimen percentages in all areas decreased from an average of 0.020% pre-implementation to an average of 0.003% post-implementation with a $p < 0.001$. See Figure 2 below for graphical interpretation of the results. See Table 1 below for numerical interpretation of the results.

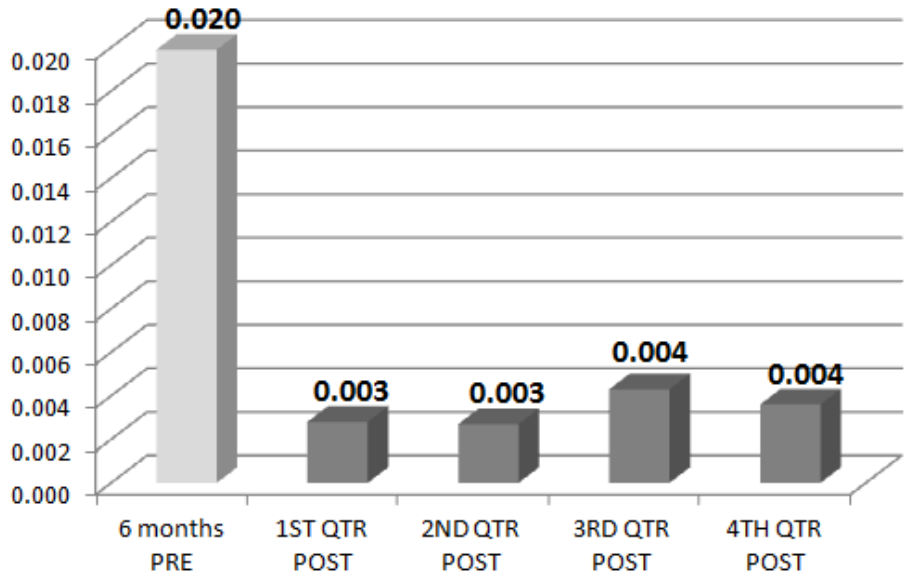

Figure 2. Average percentage of mislabeled specimens pre and post implementation of specimen collection technology.

	6 Months PRE	Intervention Month	1st QTR POST	2nd QTR POST	3rd QTR POST	4th QTR POST	12 Month Post Total	p Value
Total Mislabeled Count	22	2	1	0	2	2	5	
Total Unlabeled Count	23	4	2	3	3	2	10	
Total Both Count	**45**	**6**	**3**	**3**	**5**	**4**	**15**	
Total Number of Specimens Collected	**226286**	**35058**	**107251**	**113019**	**115876**	**112036**	**448182**	
Total Mislabeled %	0.010%	0.006%	0.001%	0.000%	0.002%	0.002%	0.001%	*** <0.001**
Total Unlabeled %	0.010%	0.011%	0.002%	0.003%	0.003%	0.002%	0.002%	*** <0.001**
Total Both %	**0.020%**	**0.017%**	**0.003%**	**0.003%**	**0.004%**	**0.004%**	**0.003%**	*** <0.001**

* Indicates statistical significance ($p < 0.05$)

Table 1. Mislabeled specimen counts and average percentages pre and post implementation of specimen collection technology

Collection Turnaround Time

Collection turnaround times greater than sixty minutes decreased following implementation of specimen collection technology by an average of 27% ($p < 0.001$). Each unit

as well as the total unit average of collection turnaround times decreased to fewer than 6% of samples greater than sixty minutes (from pre-implementation scores on average 30%). See Figure 3 below for graphical representation of the results and Table 2 for numerical representation of the results.

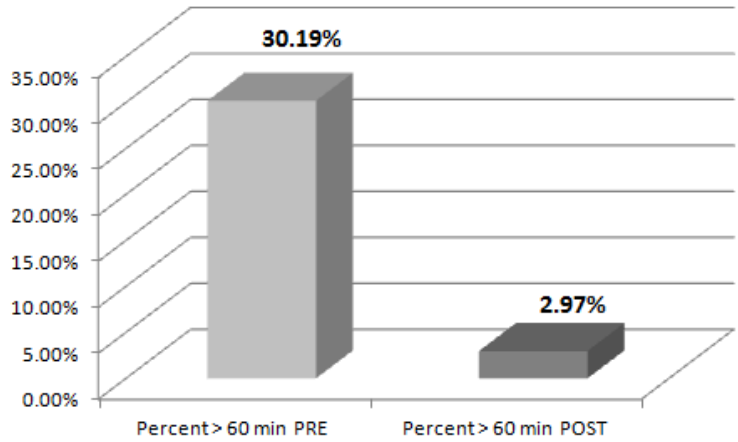

Figure 3. Average percentage of collection turnaround time greater than 60 minutes pre and post implementation of specimen collection technology

	Percent Greater than 60 min PRE	Percent Greater than 60 min POST	P-value Chi Square test of significance
ER	8.17%	1.30%	* $p < 0.0001$
Labor and Delivery	32.23%	4.27%	* $p < 0.0001$
L&D Nursery	36.36%	4.60%	* $p = 0.0001$
Mother Baby	18.64%	0.81%	* $p < 0.0001$
Mother Baby Nursery	21.88%	1.27%	* $p < 0.0001$
NICU	35.42%	3.12%	* $p < 0.0001$
Pediatrics	18.18%	5.88%	$P = 0.1918$ *sample size too small*
MEDSURG (without phlebotomy team collections)	66.44%	5.07%	* $p < 0.0001$
ICU/IMC	50.19%	3.29%	* $p < 0.0001$
TOTAL	**30.19%**	**2.97%**	*** $p < 0.0001$**

Table 2. Unit based and Total Percentages of Collection Turnaround Times greater than 60 minutes pre and post implementation of specimen collection technology

DISCUSSION

Following implementation of specimen collection technology, both mislabeled specimen percentages and collection turnaround times were significantly decreased. Of interest to note is that the average mislabeled specimen percentage following implementation of 0.003% was less than the best reported post-implementation rate from the literature of 0.005%[10]. Collection turnaround times were also much better than the reported figures in literature, with collection times reduced by an average of 27% following implementation, compared to the best reported post-implementation decrease in the literature of 13%[11].

Though every opportunity was taken to design an error free system, the implementation of technology can only be successful if standard operating procedures are followed. The study was conducted at a single community teaching hospital, and the units involved had different workflows which could contribute to slight differences in specimen collection processes and procedures. Electronic systems can introduce new sources of error when workarounds are utilized. Additionally, different types of clinical staff collecting specimens with varying levels of education and experience have the potential to introduce elements of human error within the system. Future investigation is required to understand why clinicians may choose to circumvent use of the technology. The continued existence of an occasional mislabeled specimen following implementation also reinforces the need for ongoing auditing and education to allow for continued system improvement over time.

Several other unanticipated benefits were realized by implementing specimen collection technology. One benefit was improved communication between nursing and laboratory staff. This was due to the fact that following implementation, nursing and phlebotomy had ways to run

reports in the system to see if the specimen had already been collected or was still due to be collected. The system also contained netting technology that launched when a patient wristband was scanned identifying specimens ordered to be collected by other clinician types within a four-hour window, decreasing the number of sticks the patient potentially had to experience and helping to reduce the number of missed collections. Another realized benefit was increased compliance with required elements on the specimen label, since anything entered in the system would automatically print on the collection labels. Lastly, there was the benefit of the increased ability to track and monitor the specimen collection process, and identify exactly what was occurring at the bedside through audits.

Several underlying assumptions relate to the specimen collection technology implementation. The first was that adequate time had been spent prior to implementation to optimize the technology for each specialty area in discussing and defining the best processes for each unique workflow. It is critical that key stakeholders are involved in the build/design process, so that important workflow decisions can be made.

The second consideration is the need to have enough available wireless/tethered scanners and portable label printers to suit the busiest unit workflows without disruption. Hardware and application needs drive the requirement of adequate funding support. It is also imperative that all available technology has been tested and proven to be working correctly in the confines of the hospital environment. A robust wireless network must be available to handle additional wireless workflow without causing issues or delays in scanning, printing specimen labels, or writing data into the electronic record.

A final consideration is that all end users should be given standardized education prior to implementation. Adequate funding must be in place to support the paid time for staff training. Once users have been trained, they are expected to use the technology at all times, barring system downtime or emergent patient situations. Understanding there is a learning curve associated with utilizing new technology, all system fall outs should be tracked and reported back to the end users in a timely fashion to promote continuous quality improvement.

CONCLUSION

Implementing a specimen collection system fostering positive patient identification with bedside labeling and scanning significantly reduced the mislabeled specimen rate at a community teaching hospital. This is important, as mislabeled specimens contribute to misdiagnosis, incompatible blood transfusions, delayed treatment or treatment decisions based on incorrect information, and decreased patient satisfaction. Specimen collection technology also streamlined the specimen collection process, significantly reducing collection turnaround times. Improving efficiency of the specimen collection process is important, as faster access to lab results reduces healthcare costs and improves the quality of care provided to patients. Many factors contribute to compliance with utilizing new specimen collection technology. In order to prevent workarounds, policies defining required system use, auditing and feedback procedures, and accountability measures should be considered and enacted prior to implementation of specimen collection technology.

CONTRIBUTORS

All listed authors have substantially contributed to the conception and design, or analysis and interpretation of the data and were involved in drafting or revising the manuscript and approved the final published version.

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COMPETING INTERESTS

None.

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Appendix A: Data Collection Form for Recording Collection Turnaround Times

Nursing Unit: ☐ NICU ☐ Labor & Delivery ☐ Mother/Baby

Type of Specimen: ☐ CBC ☐ BMP ☐ CRP ☐ Bilirubin

Data Collection Tool – Specimen Counts per Third Week of Each Month:

Collection Time	Pre Implementation	Intervention	Post Implementation 1	Post Implementation 2	Post Implementation 3	Post Implementation 4
Under 60 Minutes						
Over 60 Minutes						

Appendix B: Data Collection Form for Recording Monthly Mislabeled Specimen Rates

Nursing Unit: ☐ NICU ☐ Labor & Delivery ☐ Mother/Baby

Data Collection Tool – Specimen Counts and Mislabeled Specimen Rates per Month:

Collection Time	Pre Implementation	Intervention	Post Implementation 1	Post Implementation 2	Post Implementation 3	Post Implementation 4
Mislabeled Specimen Count						
Total Specimens Collected						
Mislabeled Specimen Rate						

Appendix C: Evaluation Plan – Mobilab Specimen Collection Implementation

Goal:	Measurable Objectives	Activities
To evaluate the specimen collection technology implementation in the maternal child health units at a community teaching hospital	1. Immediately following Mobilab implementation in the maternal child health division, the mislabeled specimen rate will fall below the internal laboratory best practice benchmark of 0.0100%, as measured by laboratory quality data. 2. In the first month following Mobilab implementation in the maternal child health division, 90% of all specimens will have a collection turnaround time of less than or equal to 60 minutes, as measured by laboratory specimen collection statistics	1. Multidisciplinary specimen collection team develops evaluation plan 2. Hold regular workflow meetings to analyze needs and make evaluation decisions 3. Define data/metrics for project 4. Pre-implementation data collection 5. Post-implementation data collection 6. Post implementation - weekly feedback to users with retraining when necessary 7. Statistical evaluation of data 8. Revision of project elements as needed per evaluation results 9. Report outcomes to stakeholders and disseminate findings