

**Implementation of Barcode Tracking to Prevent Surgical Pathology Specimen Loss**

Tiffany A. Fare

Under Supervision of

Shannon Hansen

Second Reader

Marilyn Miller

Clinical Site Representative

Rebecca Qualey

A DNP Project Manuscript  
Submitted in Partial Fulfillment of the Requirements for the  
Doctor of Nursing Practice Degree

School of Nursing, University of Maryland at Baltimore

May 2025

**Author Note**

There are no known conflicts of interest to disclose.

Correspondence concerning this paper should be addressed to Tiffany Fare, University of Maryland School of Nursing, 655 W. Lombard Street, Baltimore, MD 21201, United States.

Email: [tfare@umaryland.edu](mailto:tfare@umaryland.edu)

### Abstract

**Problem:** The loss of biological specimens jeopardizes patient safety by causing diagnostic delays or errors. Over three years, an academic hospital's Endoscopy Suite lost three surgical pathology specimens—classified as “Never Events” by the National Quality Forum—highlighting vulnerabilities in the specimen handling process. Manual documentation and electronic label printing create tracking inconsistencies and an unclear chain of custody. Evidence supports electronic tracking to mitigate these risks and improve patient outcomes.

**Purpose:** This quality improvement project aimed to eliminate surgical pathology specimen loss in an academic hospital's Endoscopy Suite by implementing barcode scanning for specimen tracking. This approach reduces pre-analytical errors and enhances patient safety for adults undergoing endoscopic procedures. **Methods:** The project required structural and process changes, including installing barcode tracking hardware and software and transitioning from paper documentation. The Project Lead and Unit Champions provided on-site training and support, while biweekly multidisciplinary meetings addressed staff concerns. Staff adherence to scanning protocols was monitored via electronic health record reports. **Results:** During the 13-week implementation, 3,067 specimens were processed using barcode tracking, with a median staff adherence rate exceeding 94% at each checkpoint. After staff re-education, adherence improved, particularly at the ‘OR Room’ checkpoint. Most importantly, no specimens were lost, demonstrating significant improvements in specimen management and patient safety.

**Conclusion:** Barcode scanning significantly improved adherence and eliminated specimen loss, reinforcing its effectiveness in specimen management. Continued training and targeted interventions could further enhance compliance, ensuring long-term reliability and patient safety.

*Keywords:* specimen loss, barcode tracking, quality improvement, pre-analytical errors

### **Implementation of Barcode Tracking to Prevent Surgical Pathology Specimen Loss**

Between 2021 and 2024, an academic hospital's endoscopy suite lost three irreplaceable biological specimens. The National Quality Forum (NQF) classifies specimen loss incidents as a 'Never Event' or 'Serious Reportable Event'. As defined by the NQF, Never Events are preventable clinical incidents that can cause harm to patients and potentially disrupt medical diagnosis and management. Although rare, such specimen losses underscore significant risks in pre-analytical specimen management. With over 13,000 procedures performed annually in the endoscopy suite, there is a clear need for a standardized protocol for specimen management to prevent future occurrences that could impact patient care and safety.

A fishbone diagram (see Figure 1) was used to analyze the contextual factors contributing to specimen loss in the Endoscopy Suite. Key root causes include an unclear chain of custody process, ineffective communication, inconsistent documentation practices, and the equipment available across specimen processing areas. Additionally, an analysis of the broader enterprise of the extended hospital system revealed critical vulnerabilities in pre-analytical handling, including issues with pre-printed specimen labels and the absence of chain-of-custody documentation in 32% of cases.

### **Available Knowledge and Specific Aims**

This quality improvement (QI) project aimed to eliminate the loss of surgical pathology specimens in the Endoscopy Suite by enhancing pre-analytical handling processes. Specifically, the project implemented a standardized protocol to ensure consistent and reliable specimen management across the department. The pre-analytical phase encompasses all steps from specimen collection through transport to the laboratory. Errors during this phase—such as mislabeling, misplacement, or inadequate documentation—pose serious risks, including

specimen loss, delays, or misidentification. The project sought to reduce variability, minimize errors, and promote patient safety by standardizing procedures during this critical phase.

A literature review was conducted to identify best practices for standardizing specimen management and strengthening chain-of-custody documentation. The CINAHL (Cumulative Index to Nursing and Allied Health Literature) database was used for the initial search.

Keywords included specimen tracking, management, loss, RFID tracking, and preanalytical errors. Search parameters were limited to peer-reviewed literature published within the last five years, prioritizing Level I studies such as randomized controlled trials and systematic reviews.

Due to limited findings, the search was expanded to include Level II and III studies from the past ten years.

The systematic review adhered to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency and reproducibility (see Appendix B). Of the 6,117 records initially identified, 5,942 were excluded using automation tools. The remaining 251 were manually screened, and 72 were retrieved for full review. Only 21 were accessible for in-depth analysis due to availability restrictions. Studies were excluded if they represented Level IV or V evidence, lacked relevance, or had inconsistent results. The final studies were appraised using the Johns Hopkins Nursing Evidence-Based Practice (JHNEBP) tool (Appendix C) and rated as “B” or “C” quality based on sample size and reliability of conclusions (Johns Hopkins Health System, 2025).

Findings consistently reported high rates of pre-analytical errors in specimen handling. The literature supports the use of electronic tracking systems such as RFID and barcode technologies to reduce these errors. These tools automate documentation, standardize chain-of-custody protocols, minimize human error, and contribute to improved patient safety and

operational efficiency (Norgan et al., 2020; Saathoff et al., 2018; Steelman et al., 2016).

Implementing such technology aligns with broader trends in healthcare digital transformation and is a key recommendation for improving specimen management.

### **Rationale**

The Framework of Complex Innovations (see Figure 2) served as the guiding structure for this quality improvement (QI) project. Originally developed and tested in the manufacturing industry, the framework has since been successfully adapted to complex healthcare settings (Greenhalgh et al., 2004; Helfrich et al., 2007). Greenhalgh et al. (2004) synthesized key theories of diffusion and implementation, while Helfrich et al. (2007) operationalized the framework for application in large healthcare organizations. Their work identified several essential factors for successful implementation: management support, a receptive implementation climate, adequate resource availability, alignment between the innovation and organizational values (innovation-values fit), and the presence of champions.

These key elements guided the implementation of the barcode scanning initiative. Prior to the rollout, support was obtained from the unit manager and director, and clinical champions were engaged to encourage staff participation. Involving experienced staff helped create a positive environment for change and increased readiness among the team. Access to necessary resources, including software and hardware, was critical and made possible through organizational support.

### **Methods**

#### **Context**

The Project Lead (PL) and Clinical Site Representative (CSR) conducted a preliminary site visit to evaluate the site's existing specimen management processes, identify resource gaps,

and anticipate potential barriers to implementation or sustainability. As part of this visit, informal interviews and staff observations were conducted to assess frontline staff's receptiveness to change and identify concerns related to workflow integration. Notable barriers included staff access and permissions for the electronic health record (EHR), as Unit Associates had not previously utilized the EHR, along with potential hardware challenges that followed the installation of new equipment.

Before implementation, the tracking and documentation of pathology specimens followed a hybrid process that involved manual documentation of transportation and chain of custody, along with electronic label printing and resulting. The site's pre-implementation specimen management process was outlined in Appendix D. This hybrid method revealed areas of inconsistency in clinical practice. The use of manual documentation, with numerous individuals handling specimens, made the process susceptible to human error. Additionally, the environment presented structural challenges, including the complex geographical layout of the unit, the smaller size of the specimen holding area, and the significant distance between the Endoscopy Suite and the pathology laboratory.

### **Interventions**

To proactively address these barriers, a list of staff requiring adjustments to EHR access was submitted to the appropriate department for correction. Information Technology (IT) specialists were also regularly engaged throughout the process to manage hardware-related concerns. These efforts underscored the importance of thoroughly understanding existing specimen management processes to address gaps and implement sustainable improvements. A standardized electronic specimen tracking process was implemented to reduce the risk of surgical pathology specimen loss in the Endoscopy Suite of an academic medical center. The

proposed process flow for specimen management, outlined in Appendix E, replaced the previous manual documentation process. The specimen tracking navigator is a function that uses barcode scanning to electronically track specimens at each checkpoint throughout the transportation process from the procedural area to the respective pathology laboratory. This method addressed the specimen chain of custody through electronic documentation of each specimen, including the collection time, the unit personnel who handled the specimen between each checkpoint, and arrival and departure times. This created an accurate timeline of each specimen's journey during the pre-analytical phase.

A Gantt chart (see Appendix F) was created to assist with planning and tracking the project implementation. This chart outlines the timeline for key activities, including staff training in September 2024, 13 weeks of monitoring and adjustments, and regular intervals for data analysis. The Gantt chart provided a visual roadmap of the QI project, ensuring all stakeholders were aligned with project timelines and responsibilities.

Regardless of the preparation, several barriers to implementation were observed and addressed. For instance, the Endoscopy Suite staff faced many time constraints for receiving the necessary education before going live, limiting the amount of in-person training and preparation. To address this, the project lead and CSR spent the first two days of implementation on-site to assist staff in the transition and answer questions. Additionally, barcode scanners initially had technical issues, which were addressed on-site using calibration barcodes.

### **Measures**

Several key structure, process, and outcome goals were identified for the project. Key structural goals included ensuring that all procedural and specimen areas have the necessary hardware and software, and that staff handling specimens have appropriate EHR access. The

process goal was to achieve 100% staff adherence to barcode scanning at each checkpoint.

Finally, the outcome goal was for all specimens sent to the laboratory to have electronic tracking documentation and be received accordingly.

Individuals utilizing the new specimen tracking process included all staff who handle specimens between the procedural areas within the Endoscopy Suite and the pathology laboratory. The intervention applied to all patients who underwent procedures performed in the Endoscopy Suite and required surgical pathology specimen analysis. Two methods were used to accurately measure staff adherence with the specimen tracking navigator within the EHR. EHR-generated computerized reports were used to measure scanning adherence for all surgical pathology specimens. Adherence rates were calculated by dividing the number of specimens scanned at each checkpoint by the number received for accessioning in the laboratory. Additionally, for rush specimens directly handed off from the procedural area nurse to the unit associate, the chain of custody had to be documented by adding a comment in the tracking navigator. This documentation was not included in the EHR report, and manual auditing was conducted through chart reviews by the unit champions, with support from senior nursing staff as needed.

Surgical pathology specimen loss was measured using de-identified data collected and analyzed from a computerized EHR report. It was calculated using the number of specimens received in the laboratory as the numerator and the number of specimens documented as 'sent' as the denominator. The CSR and project lead generated a computerized report every Monday that included data from the previous week, detailing the date and scanning time of each surgical pathology specimen at each checkpoint. The project lead then analyzed and disseminated the data to stakeholders weekly via email, including the run chart as it progressed.

To ensure equity and inclusion of all eligible populations, every adult undergoing endoscopic procedures requiring the collection of surgical pathology specimens was included. Data analysis was conducted using data collection in conjunction with the weekly manual transfer of EHR report totals into REDCap throughout the data collection period. Data entered into the REDCap database was displayed as a post-intervention run chart with weekly data points for each specimen scanning checkpoint.

### **Ethical Considerations**

Non-Human Subject Research determination from the Human Research Protections Office (HRPO) of the UMSOM Institutional Review Board (IRB) was obtained before project implementation. The project site's IRB process followed the site's IRB policy. Deidentified data was collected from the EHR and entered into the REDCap database, a secure, password-protected server with dual authentication. There are no conflicts of interest to disclose. The project lead complied with the Health Insurance and Accountability Act (HIPAA) and the Collaborative Institutional Training Initiative (CITI) certifications.

Measures to protect privacy at the project site included using private work areas, password-protected accounts, and two-factor authentication where available. The CSR deidentified the data to maintain confidentiality upon running the report. Aggregated project outcomes were communicated to the site for discussion regarding the quality improvement effort.

### **Results**

During the 13-week barcode scanning implementation in the Endoscopy Suite, 3,067 surgical pathology specimens were collected, with no instances of specimen loss. Average scanning adherence throughout the period was 91% at the 'OR Room' checkpoint, 94% at 'Specimen Room In,' 99% at 'Specimen Room Out,' and 98% at 'Pathology Holding In'

(Appendix G). The run chart in Appendix H displays weekly adherence trends for each checkpoint. ‘Specimen Room Out’ and ‘Pathology Holding In’ consistently maintained adherence rates above 95%, with minimal variation, often reaching 99–100%.

In contrast, the ‘OR Room’ checkpoint exhibited greater variability early in the implementation, with adherence fluctuating around the median during the first five weeks. Targeted re-education occurred in Week 5, and adherence improved markedly, resulting in a sustained shift of seven consecutive weeks (weeks 7-13) above the median line. Appendix I illustrates this sustained shift, highlighting the significant increase in scanning adherence in ‘OR Room’ compliance during the second half of the implementation. This pattern suggests a meaningful and sustained improvement in process reliability at this checkpoint.

### **Discussion**

The barcode scanning implementation yielded encouraging results, particularly at the latter checkpoints, where adherence remained consistently high. The stability observed at ‘Specimen Room Out’ and ‘Pathology Holding In’ reflects substantial process control, with long runs of high adherence rates. This consistency indicates well-integrated workflows and staff familiarity with barcode scanning procedures in those areas.

The variability observed at the ‘OR Room’ checkpoint in the initial weeks was expected, given that it served as the first point of contact in the chain of custody and involved more steps than the subsequent checkpoints. The early fluctuations and lack of clear trends during weeks 1–5 may indicate staff resistance to change, and a learning curve related to new technology and process expectations. However, following the targeted staff re-education initiative in week five, a notable improvement in adherence was observed. There was a distinct upward trend and several runs of above-average data points post-intervention, suggesting that the re-education effectively

addressed barriers to compliance. This sustained increase in adherence at the 'OR Room' checkpoint not only improved the overall reliability of the barcode scanning process but also showcased the value of iterative education and frontline engagement.

### **Conclusion**

Implementing a barcode-based electronic tracking system in the Endoscopy Suite effectively standardized the handling process for surgical pathology specimens, eliminating specimen loss over a 13-week period. This initiative demonstrated that real-time electronic tracking enhances chain-of-custody documentation and significantly reduces the risk of specimen loss, which is considered a serious patient safety concern.

Adherence rates consistently exceeded 94% across all scanning checkpoints, establishing the intervention as a reliable and sustainable method for preventing errors in pre-analytical specimen management. Importantly, no specimens were lost following implementation, highlighting the system's effectiveness in addressing a critical gap in patient safety. As previously mentioned, the loss of each specimen can result in repeat procedures, delayed or missed diagnoses, extended hospital stays, litigation, legal costs, and regulatory penalties. There is limited data on the cost of lost specimens, as it varies widely depending on the circumstances of the event. However, Sandberg, Wallace, & Dierks (2005) provide a conservative estimate of \$6,000 per lost specimen, not including litigation and legal costs. Overall, preventing specimen loss results in a substantial return on investment.

Future efforts should focus on maintaining adherence through ongoing staff education, periodic process evaluations, and leveraging technology-driven solutions to streamline specimen management further. Expanding barcode tracking to other procedural areas within the institution could enhance patient safety and operational efficiency across the healthcare system.

### References

- Álvarez-López, Y., Franssen, J., Narciandi, G. Á., Pagnozzi, J., Arrillaga, I. G., & Las-Heras, F. (2018). RFID technology for management and tracking: e-Health applications. *Sensors*, *18*(8), 2663. <https://doi.org/10.3390/s18082663>
- Anwar, S., Rehman, F., & Hameed, S. (2023). Analysis of near-miss events and errors in handling thyroid specimens: A gross room experience from a pathology lab. *Biomedica*, *39*(2), 84–90.
- Cadamuro, J., Baird, G., Baumann, G., Bolenius, K., Cornes, M., Ibarz, M., Lewis, T., Lima-Oliveira, G., Lippi, G., Plebani, M., Simundic, A., von Meyer, A., & on behalf of the European Federation for Clinical Chemistry and Laboratory Medicine (EFLM) Working Group for Pre-analytical Phase (WG-PRE). (2022). Pre-analytical quality improvement: An interdisciplinary journey. *Clinical Chemistry and Laboratory Medicine (CCLM)*, *60*(5), 662–668. <https://doi.org/10.1515/cclm-2022-0117>
- Dang, D., Dearholt, S., Bissett, K., Ascenzi, J., & Whalen, M. (2022). *Johns Hopkins evidence-based practice for nurses and healthcare professionals: Model and guidelines* (4th ed.). Sigma Theta Tau International.
- Diallo, A. O., Kiemtoré, T., Bicaba, B., Médah, I., Tarbangdo, T. F., Sanou, S., Soeters, H. M., Novak, R. T., & Aké, H. F. (2019). Development and implementation of a cloud-based meningitis surveillance and specimen tracking system in Burkina Faso, 2018. *The Journal of Infectious Diseases*, *220*(Supplement\_4), S198–S205. <https://doi.org/10.1093/infdis/jiz376>
- Eccher, A., Tos, A. P. D., Scarpa, A., L'Imperio, V., Munari, E., Troncone, G., Naccarato, A. G., Seminati, D., & Pagni, F. (2023). Cost analysis of archives in the pathology laboratories:

from safety to management. *Journal of Clinical Pathology*, 76(10), 659–663.

<https://doi.org/10.1136/jcp-2023-209035>

Greenhalgh, T., Robert, G., Macfarlane, F., Bate, P., & Kyriakidou, O. (2004). Diffusion of innovations in service organizations: systematic review and recommendations. *Milbank Quarterly*, 82(4), 581–629. <https://doi.org/10.1111/j.0887-378X.2004.00325.x>

Halwani, F., Li, W. C., Banerjee, D., Lessard, L., Amyot, D., Michalowski, W., & Giffen, R. (2016). A real-time dashboard for managing pathology processes. *Journal of Pathology Informatics*, 7(1), 24. <https://doi.org/10.4103/2153-3539.181768>

Helfrich, C. D., Weiner, B. J., McKinney, M. M., & Minasian, L. M. (2007). Determinants of implementation effectiveness: adapting a framework for complex innovations. *Medical Care Research and Review*, 64(3), 279–303. <https://doi.org/10.1177/1077558707299887>

Holstine, J. B., & Samora, J. B. (2021). Reducing surgical specimen errors through multidisciplinary quality improvement. *Joint Commission Journal on Quality & Patient Safety*, 47(9), 563–571. <https://doi.org/10.1016/j.jcjq.2021.04.003>

Johns Hopkins Health System. (2025). *Johns Hopkins Evidence-Based Practice Model and Guidelines*. [https://www.hopkinsmedicine.org/-/media/nursing/documents/cni-documents/appendix-c\\_searching-and-screening-tool\\_2025final.pdf](https://www.hopkinsmedicine.org/-/media/nursing/documents/cni-documents/appendix-c_searching-and-screening-tool_2025final.pdf)

Le, N. T., Chit, M. M. T., Truong, T. L., Siritantikorn, A., Kongruttanachok, N., Asdornwised, W., Chaitusaney, S., & Benjapolakul, W. (2023). Deployment of smart specimen transport system using RFID and NB-IoT technologies for hospital laboratory. *Sensors*, 23(1), 546. <https://doi.org/10.3390/s23010546>

National Quality Forum. (2025). List of serious reportable events (SREs). Retrieved January 31, 2025, from [https://www.qualityforum.org/Topics/SREs/List\\_of\\_SREs.aspx](https://www.qualityforum.org/Topics/SREs/List_of_SREs.aspx)

- Norgan, A. P., Simon, K. E., Feehan, B. A., Saari, L. L., Doppler, J. M., Welder, G. S., Sedarski, J. A., Yoch, C. T., Comfere, N. I., Martin, J. A., Bartholmai, B. J., & Reichard, R. R. (2020). Radio-frequency identification specimen tracking to improve quality in anatomic pathology. *Archives of Pathology & Laboratory Medicine*, *144*(2), 189–195.  
<https://doi.org/10.5858/arpa.2019-0011-0a>
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T., Mulrow, C. D., Shamseer, L., Tetzlaff, J., Akl, E. A., Brennan, S., Chou, R., Glanville, J., Grimshaw, J., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E., Mayo-Wilson, E., McDonald, S., ... Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, *372*, n71. <https://doi.org/10.1136/bmj.n71>
- Saathoff, A. M., MacDonald, R., & Krenzischek, E. (2018). Effectiveness of specimen collection technology in the reduction of collection turnaround time and mislabeled specimens in emergency, medical-surgical, critical care, and maternal child health departments. *CIN: Computers, Informatics, Nursing*, *36*(3), 133–139.  
<https://doi.org/10.1097/cin.0000000000000402>
- Sandberg, W. S., Wallace, R. S., & Dierks, M. M. (2005). Tracking and reporting surgical specimen errors: A quality improvement strategy for pathology and operating room services. *Joint Commission Journal on Quality and Patient Safety*, *31*(2), 98–104.  
[https://doi.org/10.1016/S1553-7250\(05\)31014-9](https://doi.org/10.1016/S1553-7250(05)31014-9)
- Schwartz, M., Osborn, H., Palmieri, J., Patel, B., & Flug, J. A. (2020). Reducing errors in radiology specimen labeling through use of a two-person check. *Current Problems in Diagnostic Radiology*, *49*(5), 351–354. <https://doi.org/10.1067/j.cpradiol.2020.01.003>

Snyder, S., Favoretto, A. M., Derzon, J. H., Christenson, R. H., Kahn, S. E., Shaw, C., Baetz, R.

A., Mass, D., Fantz, C. R., Raab, S. S., Tanasijevic, M. J., & Liebow, E. (2012).

Effectiveness of barcoding for reducing patient specimen and laboratory testing

identification errors: A Laboratory Medicine Best Practices systematic review and meta-analysis. *Clinical Biochemistry*, 45(13–14), 988–998.

<https://doi.org/10.1016/j.clinbiochem.2012.06.019>

Steelman, V. M., Williams, T. L., Szekendi, M., Halverson, A. L., Dintzis, S. M., & Pavkovic, S.

(2016). Surgical specimen management: A descriptive study of 648 adverse events and near misses. *Archives of Pathology & Laboratory Medicine*, 140(12), 1390–1396.

<https://doi.org/10.5858/arpa.2016-0021-oa>

Tran, N. K., & Liu, Y. (2020). *Pre-analytical pitfalls: Missing and mislabeled specimens*. PSNet.

<https://psnet.ahrq.gov/web-mm/pre-analytical-pitfalls-missing-and-mislabeled-specimens#20>

Tozbikian, G., Gemignani, M. L., & Brogi, E. (2017). Specimen identification errors in breast

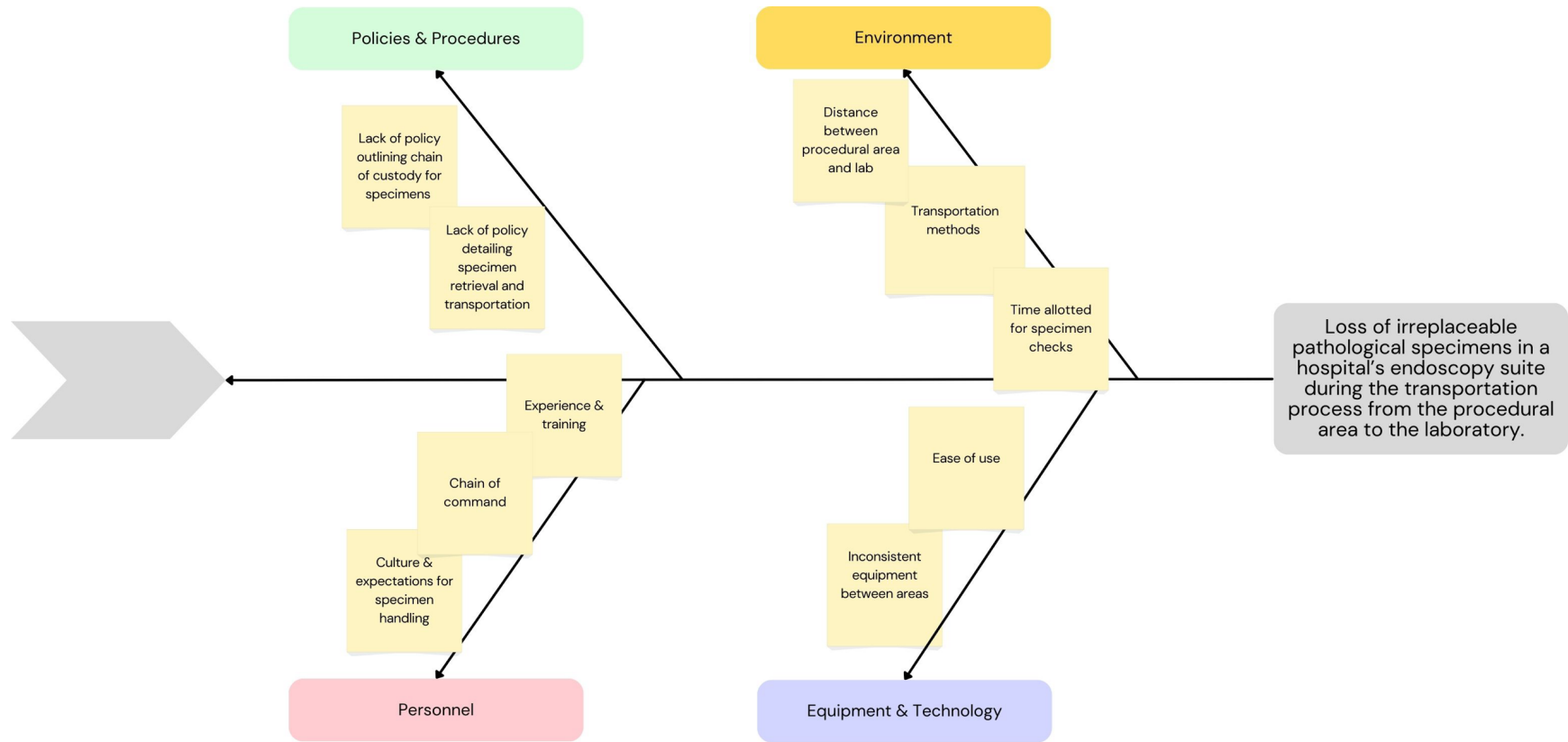
biopsies: Age matters. Report of two near-miss events and review of the literature. *Breast Journal*, 23(5), 583–588. <https://doi.org/10.1111/tbj.12797>

Yu, M. H., Lee, T. T., & Mills, M. E. (2019). The effect of barcode technology use on pathology specimen labeling errors. *AORN Journal*, 109(2), 183–191.

<https://doi.org/10.1002/aorn.12585>

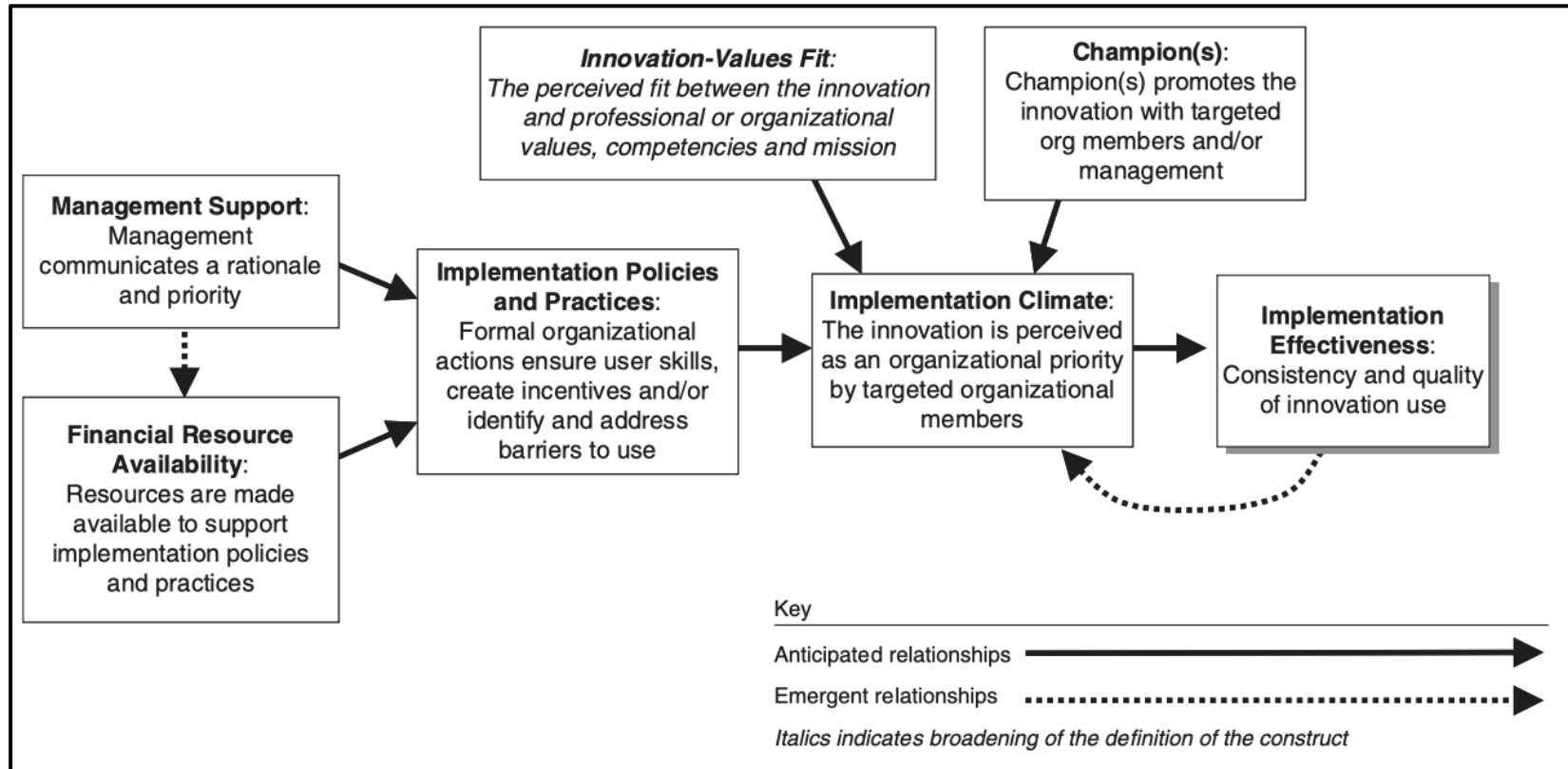
**Figure 1**

*Fishbone Diagram: Contextual Factors Related to Surgical Pathology Specimen Loss*



**Figure 2**

*Framework of Complex Innovations*



Note: Adapted from Helfrich et al., 2007.

**Appendix A**

**Evidence Review and Appraisal**

<b>Citation:</b> Anwar, S., Rehman, F., & Hameed, S. (2023). Analysis of near-miss events and errors in handling thyroid specimens: A gross room experience from a pathology lab. <i>Biomedica</i> , 39(2), 84–90.		<b>Level and Quality:</b> III-B
Purpose or Hypothesis	The objective of this study was to analyze different errors and near-miss events in the grossing of thyroid specimens in a surgical pathology gross room of a Tertiary Care Hospital in Lahore, Pakistan.	
Type of Evidence Research Design	Quantitative research (Observations & review of records) Non-experimental (no manipulation) Single group Observational	
Sample Population, Size, Setting	<b>Population:</b> Different types of thyroid specimens including lobectomies, isthusectomies, nodule excision, lobectomies with isthmusectomies, and thyroidectomies. Cytology and frozen sections were excluded from the study. <b>Size:</b> 132 thyroid specimens <b>Setting:</b> Tertiary Care Hospital in Lahore, Pakistan	
Intervention Procedures	Request forms and reports of the thyroid specimens were collected and scrutinized along with the surgical specimen status before and after grossing the specimen in the standard gross room. Surgical specimen events were classified by the specimen type and the type of event. A cross-sectional analysis was done on different thyroid specimens received at the Pathology reception of Lahore General Hospital, Lahore, Pakistan, from January 2022 to April 2023. Different types of errors involved in standard gross examinations were studied.	
Primary Outcome and Measures	Errors in the collection, handling, and interpretation of specimens were measured. Reports were reviewed by expert pathologists and subject specialists to scrutinize reports in which relevant gross information was missing.	
Results/ Conclusions	<b>Statistical results:</b> Most of the near-miss events and errors involved more than one phase (n = 69, 52.27%). Errors observed in the pre-analytical phase included the use of inappropriate fixative (15.2%), insufficient clinical information (76.5%), mislabeled jar/request form (7.6%), and loss of specimen (8%). Grossing errors included insufficient grossing notes (12.2%), cutting thick slices (10.7%), missing lesions on gross examination (9.9%), inappropriate inking (6.9%), overfilling cassette with large tissue sections (6.9%), mislabeled cassettes (93.8%), and incomplete submission of capsule (2.3%) <b>Conclusions:</b> Errors and near-miss events in handling thyroid specimens can be avoided by effective training of the handling staff and grossing residents. Collaboration between clinical wards and histopathology laboratories can also be helpful in this regard.	
<b>Citation:</b> Halwani, F., Li, W. C., Banerjee, D., Lessard, L., Amyot, D., Michalowski, W., & Giffen, R. (2016). A real-time dashboard for managing pathology processes. <i>Journal of Pathology Informatics</i> , 7(1), 24. <a href="https://doi.org/10.4103/2153-3539.181768">https://doi.org/10.4103/2153-3539.181768</a>		<b>Level and Quality:</b> III-C

Purpose or Hypothesis	The purpose of this study was to develop an electronic dashboard to monitor pathology processes in real time and allow pathology clinical management to foresee and address issues related to specimen allocation and tracking.	
Type of Evidence Research Design	Single group Observational	
Sample Population, Size, Setting	<p><b>Population:</b> Surgical specimens processed Grossing, histology, and cytology laboratories in one central location (Department of Pathology and Laboratory Medicine)</p> <p><b>Size:</b> 8 hospitals' laboratories (specimens are sent to central location for processing)</p> <p><b>Setting:</b> The Department of Pathology and Laboratory Medicine (DPLM) at The Ottawa Hospital (TOH),</p>	
Intervention Procedures	<p>The dashboard was designed and developed in two phases, following a prototyping approach.</p> <p>The first prototype was developed based and process and management needs at the site and was implemented on the computers of the Chief of the Division, the Operations Manager, and the Director of Informatics to be used in a selective manner by them. This dashboard provided data at 2-hour intervals and notified management of any processing issues after they arose.</p> <p>The second prototype followed recommended guidelines for developing business intelligence dashboards and included additional process and management needs identified by management at the site. This model was a dynamic dashboard with more frequent information in graphs and charts to allow for quick interpretation.</p>	
Primary Outcome and Measures	The dependent variable to be measured is the number of specimen processing errors and the timeliness of correction. This would theoretically be able to be pulled from data reports. However, the measurement of this DV is not mentioned in this article.	
Results/ Conclusions	Dashboard implementation helped to uncover operational inefficiencies and contributed to an improvement of turn-around time within the hospitals department. It also allowed the discovery of additional requirements, leading to a second prototype that provides finer-grained, real-time information about individual cases and specimens. Given the importance of rapid diagnostics for a number of diseases, the use of real-time dashboards within pathology departments could contribute to improving the quality of patient care beyond EORLA's.	
<p><b>Citation:</b> Le, N. T., Chit, M. M. T., Truong, T. L., Siritantikorn, A., Kongruttanachok, N., Asdornwised, W., Chaitusaney, S., &amp; Benjapolakul, W. (2023). Deployment of smart specimen transport system using RFID and NB-IoT technologies for hospital laboratory. <i>Sensors</i>, 23(1), 546. <a href="https://doi.org/10.3390/s23010546">https://doi.org/10.3390/s23010546</a></p>		<b>Level and Quality:</b> II-C
Purpose or Hypothesis	The purpose of this study was to accelerate the specimen accounting process and eliminate the specimen loss due to human error.	
Type of Evidence Research Design	Quasi-experimental	
Sample Population, Size, Setting	<p><b>Population:</b> Inpatients at the public hospital requiring specimen collection and processing</p> <p><b>Size:</b> The hospital that will be using this system has an inpatient capacity of over 1400 beds</p> <p><b>Setting:</b> Large, public hospital in Bangkok, Thailand &amp; the Central Laboratory (Department of Laboratory Medicine)</p>	
Intervention Procedures	The authors propose a specimen tube prototype and smart specimen transport box using Radio Frequency Identification (RFID) and Narrow Band – Internet of Things (NB-IoT) technology. The passive RFID tag is attached to the surface of the specimen tube and stored information such as patient records, required tests, and receiver laboratory location. The RFID reader is a wireless system	

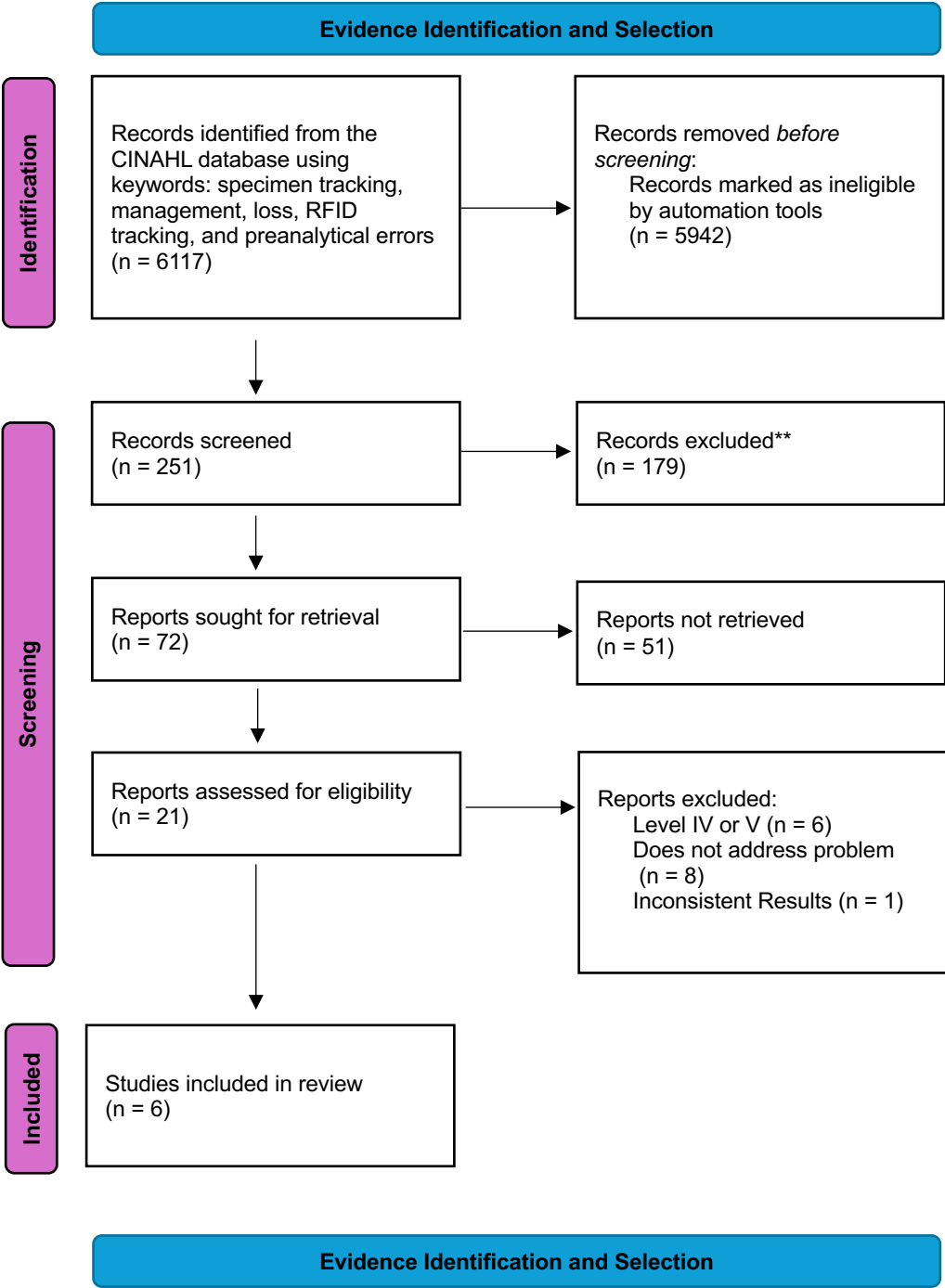
	placed at each laboratory and automatically receives data from the RFID tags and uploads it to the cloud (computer system) when the transport box is within range. The same RFID reader technology can also be used to change information connected to each sample. Additionally, the NB-IoT module is fixed to the specimen transport box and monitors the environment within the box, as well as the GPS location of the box. This information is also uploaded to the cloud. The information in the cloud has a security system that deidentifies specimens but allows doctors/ necessary personnel to monitor the transportation process of specimens as well as the quality of the smart box environment used for the specimens.
Primary Outcome and Measures	The process this implementation is attempting to improve are the length of time spent on the specimen accounting process, as well as potentially lost specimens. This article describes the development of a process change still in its pilot stages. At this stage of the process, the authors focus is on measuring the performance of both the RFID system as well as the NB-IoT system. To assess the functionality of this novel technology and process, the authors are using data extracted by the NB-IoT and RFID systems.
Results/ Conclusions	This technology is still in its initial phases of development and has not yet been implemented with actual patient specimens. However, the laboratory experiments and pilot tests at the same hospital & laboratory center demonstrated this to be an effective and practical solution. Additionally, the ability to reuse the RFID tag allows for higher return on investment.
<b>Citation:</b> Norgan, A. P., Simon, K. E., Feehan, B. A., Saari, L. L., Doppler, J. M., Welder, G. S., Sedarski, J. A., Yoch, C. T., Comfere, N. I., Martin, J. A., Bartholmai, B. J., & Reichard, R. R. (2020). Radio-frequency identification specimen tracking to improve quality in anatomic pathology. <i>Archives of Pathology &amp; Laboratory Medicine</i> , 144(2), 189–195. <a href="https://doi.org/10.5858/arpa.2019-0011-0a">https://doi.org/10.5858/arpa.2019-0011-0a</a>	
<b>Level and Quality:</b> II-B	
Purpose or Hypothesis	<b>Hypothesis:</b> Implementation of a specimen tracking system will reduce the amount of pre-analytical errors (specimen mislabeling/ loss) between specimen collection and laboratory accessioning
Type of Evidence Research Design	Quasi-experimental Non-randomized Pre-post intervention study
Sample Population, Size, Setting	<b>Population:</b> Specimens collected from patients in 4 procedural areas (Laboratory Medicine & Pathology; Dermatology; Radiology; Division of Gastroenterology in the Department of Medicine) <b>Size:</b> 55,953 samples <b>Setting:</b> Large, integrated academic medical and tertiary care center with ≈2000 hospital beds and ≈90 operating rooms
Intervention Procedures	<b>Design:</b> A radio-frequency identification specimen-tracking system was developed. Significant features included integral RFID labels (RFID tags and traditional bar codes in a single printed label) printed by point-of-care printers in collection suites; dispersed RFID readers at major transit points; and systems integration of the electronic health record, laboratory information system, and RFID tracking system to allow for computerized physician order entry driven label generation, specimen transit time tracking, interval-based alarms, and automated accessioning.
Primary Outcome and Measures	<b>DV:</b> Pre-analytical errors between specimen collection and laboratory accessioning <b>Measurement of DV:</b> Automated specimen tracking reports from RFID label/ tracking system

<p>Results/ Conclusions</p>	<p><b>Results:</b> In the 6-month postimplementation period, 6 mislabeling events occurred in collection areas using the radio-frequency identification system, compared with 24 events in the 6-month pre-implementation period (75% decrease; P = .001). In addition, the system led to the timely recovery of 3 lost specimens. Labeling expenses were decreased substantially in the transition from high-frequency to ultrahigh frequency radio-frequency identification tags.</p> <p><b>Conclusions:</b> Implementation of RFID specimen tracking prevented several potential specimen-loss events, decreased specimen recovery time, and decreased specimen labeling errors. Increases in labeling/tracking expenses for the system were more than offset by time savings and loss avoidance through error mitigation.</p>	
<p><b>Citation:</b> Saathoff, A. M., MacDonald, R., &amp; Krenzischek, E. (2018). Effectiveness of specimen collection technology in the reduction of collection turnaround time and mislabeled specimens in emergency, medical-surgical, critical care, and maternal child health departments. <i>CIN: Computers, Informatics, Nursing</i>, 36(3), 133–139. <a href="https://doi.org/10.1097/cin.0000000000000402">https://doi.org/10.1097/cin.0000000000000402</a></p>		<p><b>Level and Quality:</b> II-B</p>
<p>Purpose or Hypothesis</p>	<p><b>Purpose:</b> The purpose of this study was to evaluate the impact of specimen collection technology implementation on the 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.</p> <p><b>Hypothesis:</b> The hypothesis was that there would be a statistically significant decrease in mislabeled specimen rates and collection turnaround times across the combined units</p> <p><b>Objectives:</b></p> <ol style="list-style-type: none"> <li>1. Immediately after 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.</li> <li>2. Within the first month after specimen collection technology implementation across the defined divisions, 90% of all specimens would have a collection turnaround time of less than or equal to 60 minutes, as measured by laboratory specimen collection data.</li> </ol>	
<p>Type of Evidence Research Design</p>	<p>Quantitative/ Quasi-experimental Single center Pre-post intervention study</p>	
<p>Sample Population, Size, Setting</p>	<p><b>Population:</b> Specimens collected from patients in the emergency, med-surg, critical care, and maternal child health departments</p> <p><b>Size:</b> 448,182 specimens over 12 months</p> <p><b>Setting:</b> Community teaching hospital</p>	
<p>Intervention Procedures</p>	<p>A specimen collection system including computerized provider order entry, positive patient identification, bedside labeling, and barcode scanning was implemented across each department in phases. Implementation was staggered to provide a tailored approach to the education needs of each department.</p>	

Primary Outcome and Measures	<p><b>DV:</b> Rate of mislabeled specimens; specimen collection turnaround times</p> <p><b>Measures:</b> Laboratory specimen collection data and qualitative laboratory data over 12 months were measured using a data collection tool developed to collate data/ information related to mislabeled specimens</p>	
Results/ Conclusions	<p><b>Results:</b> Mislabeled specimen percentages in all areas decreased from an average of 0.020% pre-implementation to an average of 0.003% postimplementation, with a <math>P &lt; .001</math>. Collection turnaround times longer than 60 minutes decreased after the implementation of specimen collection technology by an average of 27%, with a <math>P &lt; .001</math>.</p> <p><b>Conclusion:</b> Implementation of specimen collection technology reduces the number of pre-analytical specimen errors in a large hospital</p>	
	<p><b>Citation:</b> Steelman, V. M., Williams, T. L., Szekendi, M., Halverson, A. L., Dintzis, S. M., &amp; Pavkovic, S. (2016). Surgical specimen management: A descriptive study of 648 adverse events and near misses. <i>Archives of Pathology &amp; Laboratory Medicine</i>, 140(12), 1390–1396. <a href="https://doi.org/10.5858/arpa.2016-0021-0a">https://doi.org/10.5858/arpa.2016-0021-0a</a></p>	<p><b>Level and Quality:</b> III-B</p>
Purpose or Hypothesis	<p>To describe the types and frequency of event reports associated with the management of surgical specimens, the contributing factors, and the level of harm associated with these events.</p>	
Type of Evidence Research Design	<p>Qualitative Descriptive/ non-experimental study Retrospective analysis Multi-center</p>	
Sample Population, Size, Setting	<p><b>Population:</b> Surgical specimens <b>Size:</b> 648 surgical specimen event reports <b>Setting:</b> &gt;50 health care facilities contributing to database reports</p>	
Intervention Procedures	<p>Retrospective review of surgical specimen adverse events and near misses during a 3-year period (2011-2013)</p>	
Primary Outcome and Measures	<p>Event reports were retrieved from the University Health System Consortium Safety Intelligence Patient Safety Organization database.</p>	
Results/ Conclusions	<p>The most common events were reported during the pre-laboratory phase, specifically involving specimen labeling, collection/preservation, and transport. The most common contributing factors were failures in handoff communication, staff inattention, knowledge deficit, and environmental issues. 8% of the events (52 of 648) resulted in either the need for additional treatment or temporary or permanent harm to the patient.</p>	

Appendix B

PRISMA Flow Diagram



**Appendix C**

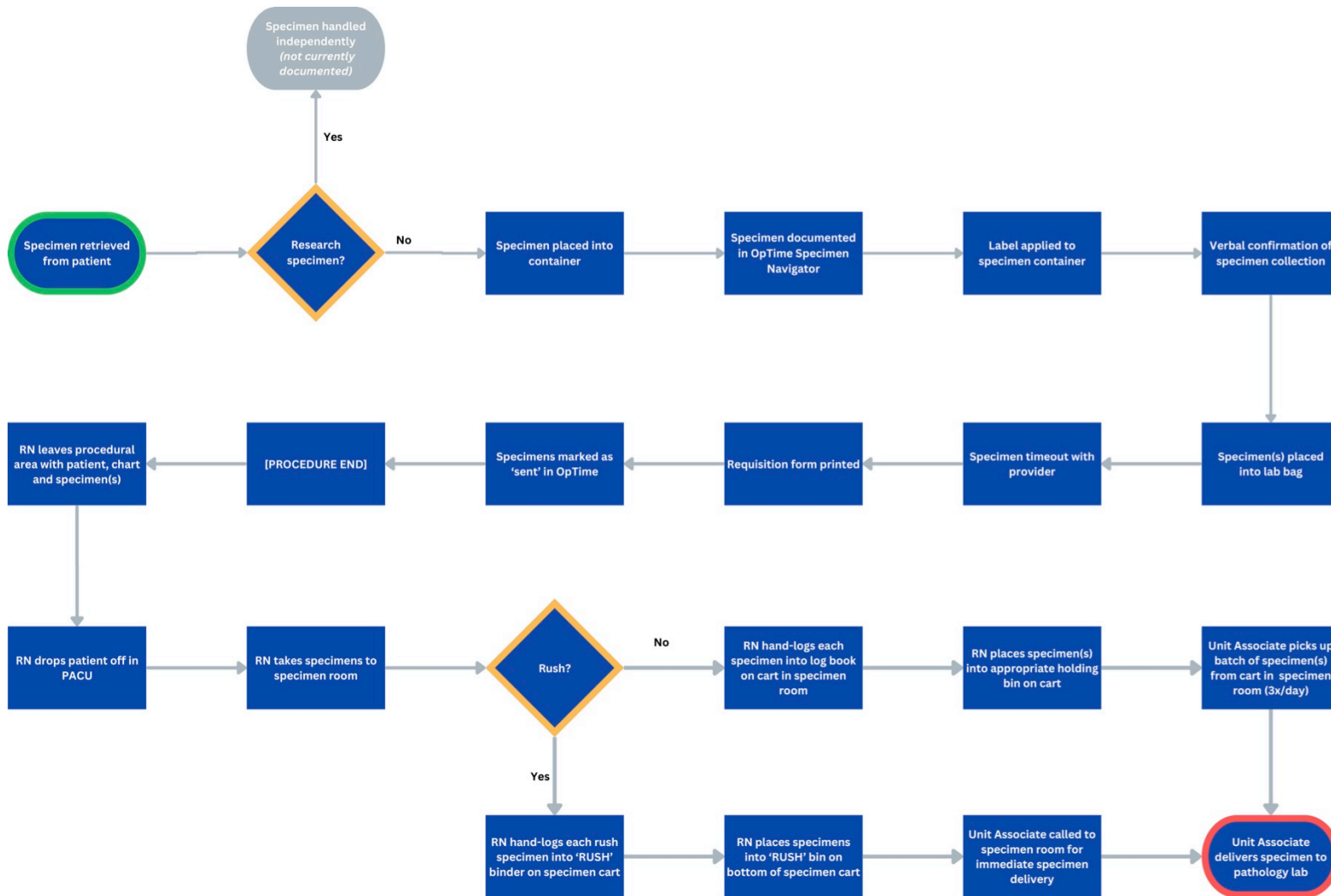
**Evidence Synthesis**

<b>Project Title:</b> Implementation of Barcode Tracking to Prevent Surgical Pathology Specimen Loss			
<b>PICOT:</b> In an academic hospital’s endoscopy suite, does the implementation of a barcode scanning tracking method compared to paper tracking improve the number of pre-analytical errors of specimen handling?			
<b>JHNEBP Model Level</b>	<b>Total Number of Sources</b>	<b>Author and Quality Rating of each study</b>	<b>Synthesis of Findings</b>
<b>Level I:</b> Experimental study · Randomized Controlled Trial (RCT) · Systematic review of RCTs with or without meta-analysis			
<b>Level II:</b> Quasi-experimental studies · Systematic review of a combination of RCTs and quasi-experimental studies, or quasi-experimental studies only, with or without meta-analysis	3 single group pretest-posttest study (Norgan et al., 2020; Saathoff et al., 2018; Le et al., 2023)	Norgan et al. (2020) B Saathoff et al. (2018) B Le et al. (2023) C	Norgan et al. (2020) and Le et al. (2023) determined that implementation of a specimen tracking system reduces specimen loss occurrences during transportation and can reduce time spent on specimen management. Norgan et al. (2020) and Saathoff et al. (2018) found that implementation of specimen collection technology significantly decreases pre-analytical errors in a large hospital setting.
<b>Level III:</b> Non-experimental study · Systematic review of a combination of RCTs, quasi-experimental, and non-experimental studies, or non-experimental studies only, with or without meta-analysis · Qualitative study or systematic review of qualitative studies with or without meta-synthesis	3 single group observational studies (Anwar et al., 2023; Steelman et al., 2016; and Halwani et al., 2016)	Anwar et al. (2023) B Steeleman et al. (2016) B Halwani et al. (2016) C	Halwani et al. (2016), Anwar et al. (2023), and Steelman et al. (2016) all concluded that specimen transportation issues were most often related to human errors during handling. Anwar et al. (2023) and Steelman et al. (2016) further described how the environment and handoff communication are major contributors to errors and near miss events.

<p><b>Level IV:</b> Opinion of respected authorities and/or reports of nationally recognized expert committees/consensus panels based on scientific evidence</p>			
<p><b>Level V:</b> Evidence obtained from literature reviews, quality improvement, program evaluation, financial evaluation, or case reports · Opinion of nationally recognized expert(s) based on experiential evidence</p>			
<p><b>Overall Quality Rating:</b> B; Good with consistent evidence; practice change is recommended</p>			

Appendix D

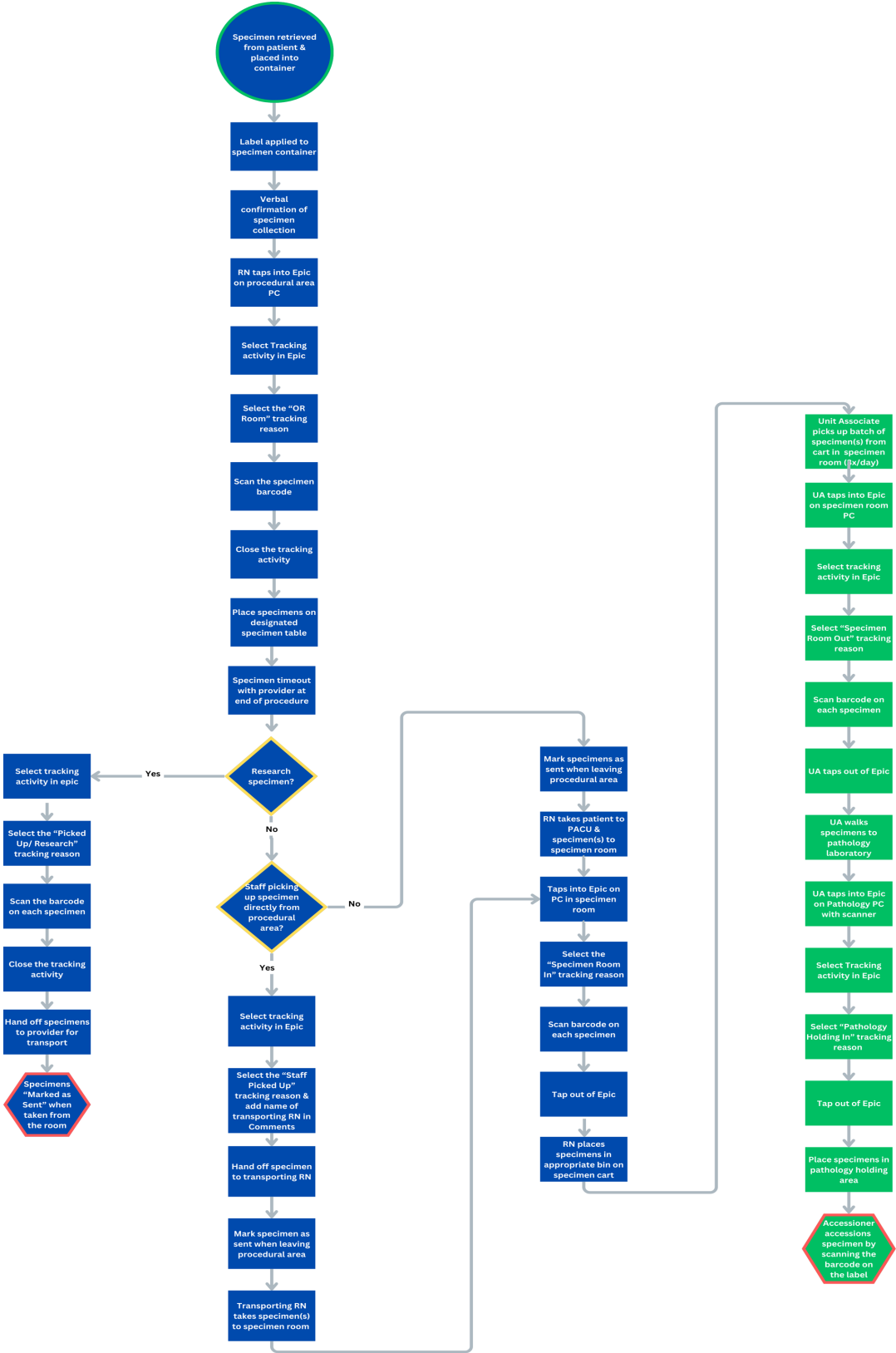
Current Surgical Pathology Specimen Management Process



BARCODE TRACKING TO PREVENT SPECIMEN LOSS

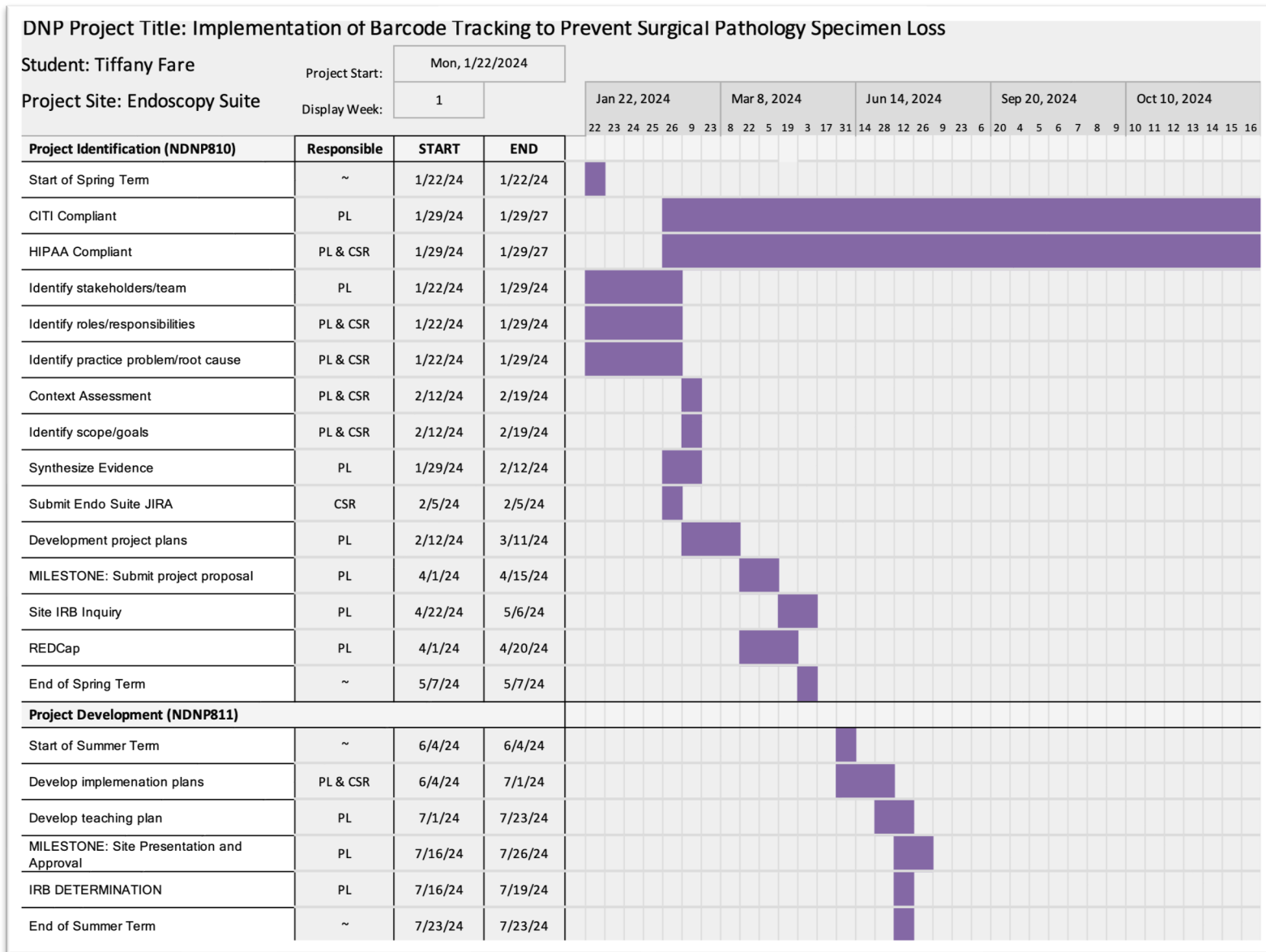
Appendix E

Proposed Surgical Pathology Specimen Management Process



Appendix F

Project Timeline: Gantt Chart



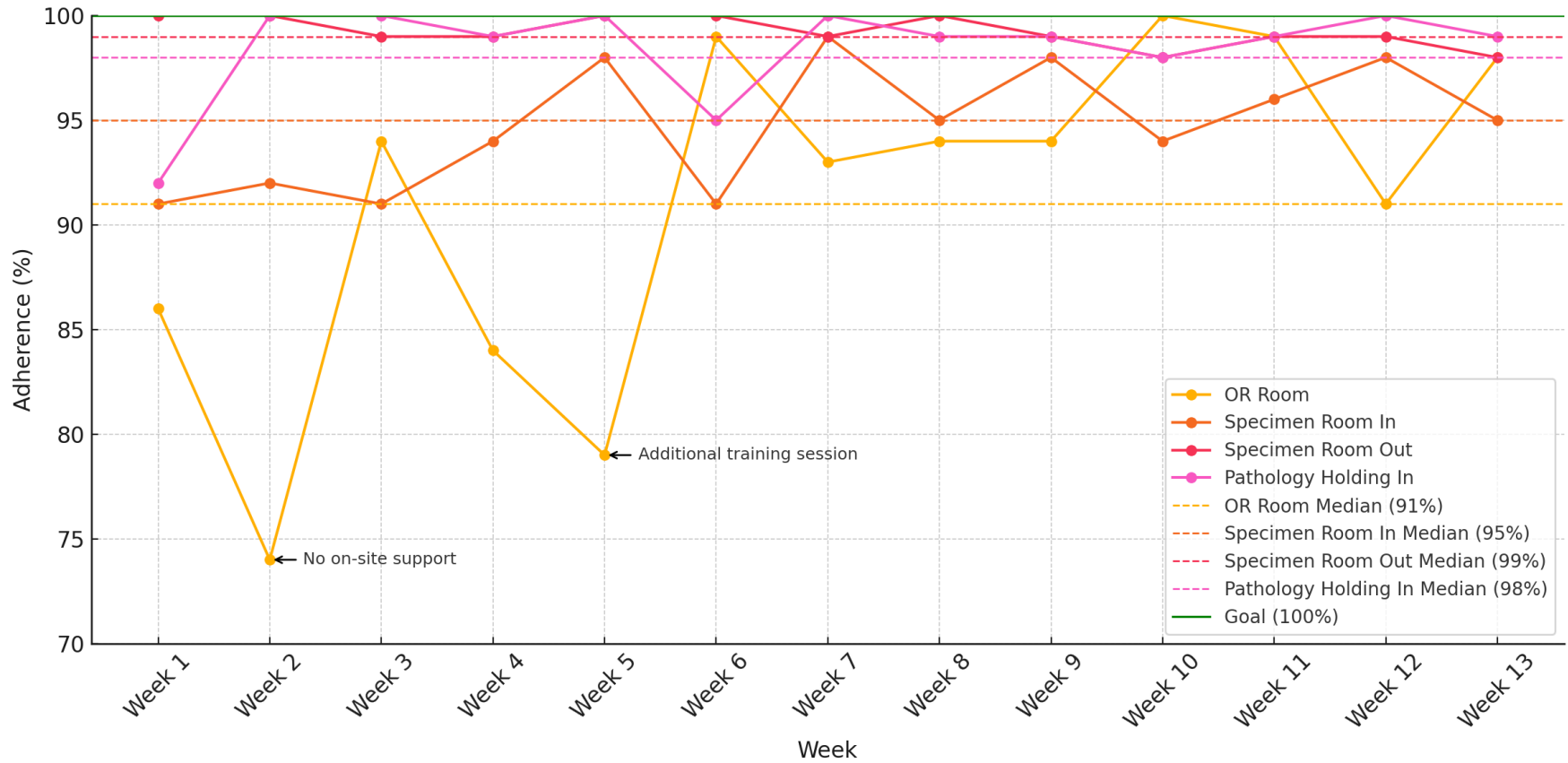


**Appendix G****Summary of Weekly Scanning Adherence**

<b>Week</b>	<b># Surgical Pathology Specimens</b>	<b>OR Room (%)</b>	<b>Specimen Room In (%)</b>	<b>Specimen Room Out (%)</b>	<b>Pathology Holding In (%)</b>
<b>1</b>	303	86%	91%	99%	91%
<b>2</b>	197	74%	92%	100%	100%
<b>3</b>	266	94%	91%	99%	100%
<b>4</b>	231	84%	94%	99%	99%
<b>5</b>	295	79%	98%	100%	100%
<b>6</b>	223	99%	91%	100%	95%
<b>7</b>	209	93%	99%	99%	100%
<b>8</b>	232	94%	95%	100%	99%
<b>9</b>	252	94%	98%	99%	99%
<b>10</b>	255	100%	94%	98%	98%
<b>11</b>	131	99%	96%	99%	99%
<b>12</b>	248	91%	98%	99%	100%
<b>13</b>	225	98%	95%	98%	99%
<b>Median Adherence</b>	3067	91%	94%	99%	98%

Appendix H

Run Chart: Specimen Tracking Adherence Over Time



Appendix I

Run Chart: 'OR Room' Checkpoint Adherence

