

INTRODUCTION

When our Breast Imaging section became part of a multi-specialty Breast Care Center, we began facing escalating exam volumes, more complex patients, and an overall increased demand on the radiologists' time. Over the years, four outside consultants had been employed to comment on the inefficiencies of the section and offer solutions. These "solutions" had limited success as they were not individualized to the section and personnel and did not fully engage the radiologists and technologists as the agents of change. Therefore, the decision was made to embark on a comprehensive quality improvement program using the Lean approach.

What is Lean?

Lean describes a system of continuous improvement in performance which was originally developed in the automotive manufacturing industry and coined the Toyota Production System. The Lean approach strives to eliminate all forms of waste within a given process, therefore requiring fewer resources to achieve the same, or increased, levels of productivity. The end goal is increased customer satisfaction; however, along the way, the work environment becomes better organized, safer, and more efficient. In recent years, Lean has also been applied in the healthcare field.

Lean Principles

- Equal involvement of and respect for all staff
- Observation and analysis of processes where they occur
- Elimination of all forms of waste, including any steps in a process that do not add value
- Standardization of work to minimize variations
- Improvement of the flow of all processes in the system
- Use of visual cues to communicate and inform
- Adding value for the customer
- Application of lean tools to collect and analyze data, improve processes, and create and sustain change.

Courtesy of Suneja A and Suneja, C. Lean Doctors.

METHODS

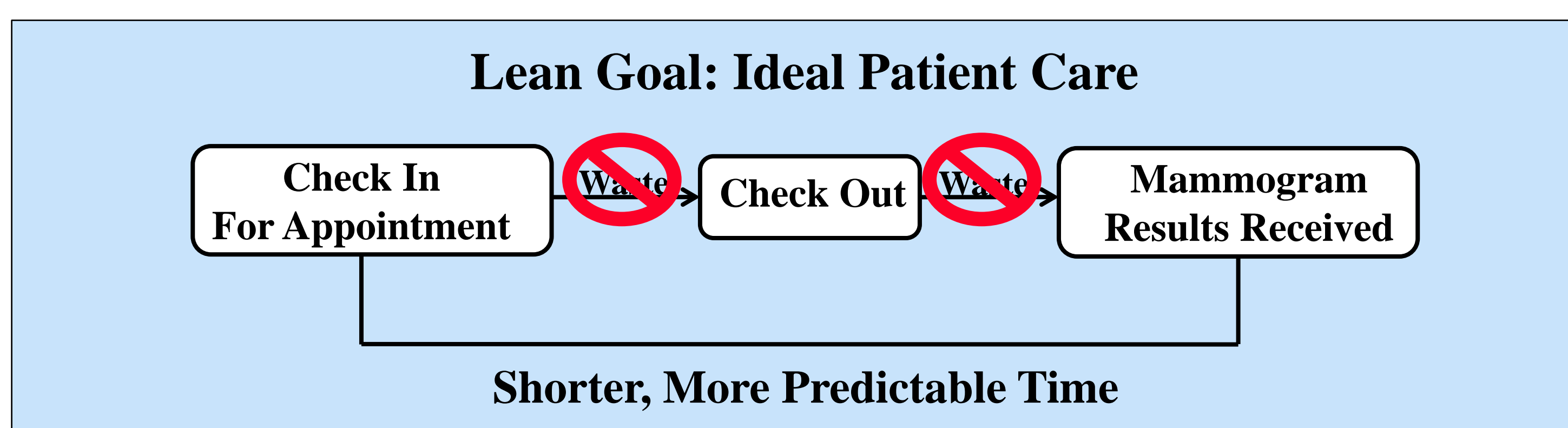
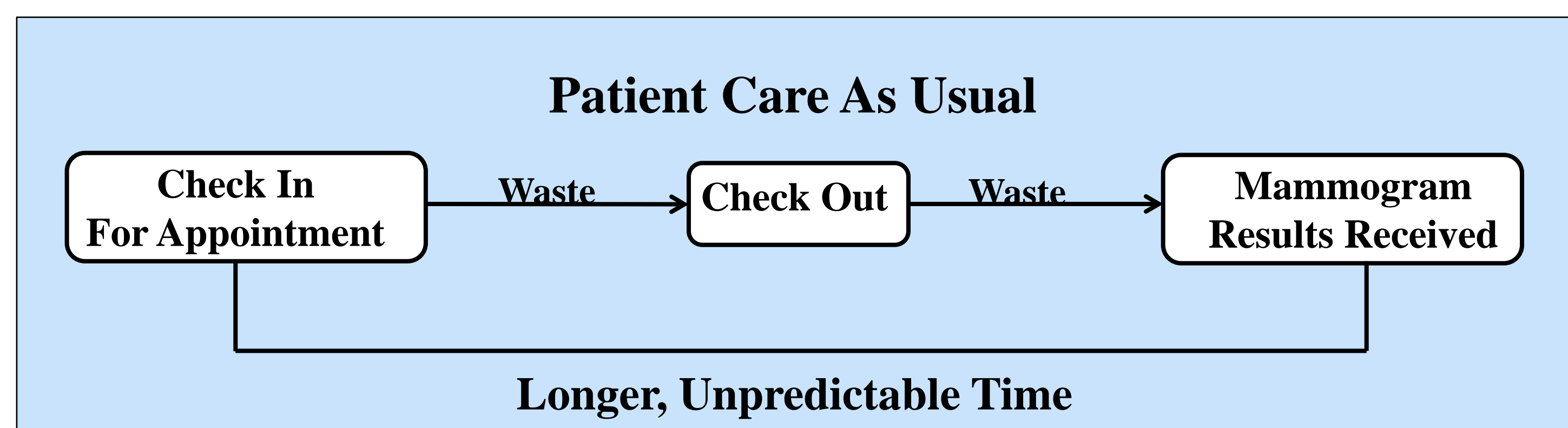
Overall Approach

A team comprised of radiologists (staff, fellows, and residents), technologists, file room personnel, information technology representatives, and administrators from our Breast Imaging section met twice a month beginning in January 2012 to learn about the Lean approach and apply it in our section. These meetings were facilitated by an engineer with training in Lean and experience in applying Lean in health care. Screening mammography was chosen as the place to begin because its workflow is the least complicated, affording the opportunity to make early gains while mastering the principles of Lean. Throughout this process, a bottom-up rather than top-down management approach was emphasized to encourage all team members to participate in identifying problems, suggesting solutions, and implementing the plans.



Patient Centered Vision

Our first step was to recognize Lean's primary focus on the patient experience. By adopting this vision, activities that the patient cares about (time with the physician or technologist) can be maximized while wastes (wait times) can be eliminated. This approach would serve as the cornerstone of our quality improvement goals.



Lean Tools: Value Stream Map

A **value stream map** is a way to layout the general steps of a given process in order to provide a framework from which to begin the Lean transformation. This technique documents the current flow of information or materials and allows for analysis and improvements to be made within a greater context. Each individual change can be viewed within the overall system, which allows for a more cohesive transition and can prevent disjointed or suboptimal efforts. The map can also be used as an important backdrop for data collection.

Value Added Activity

Activities that the customer cares about such as *time the patient spends with the technologist or radiologist*

Waste or Non-Value Added Activities

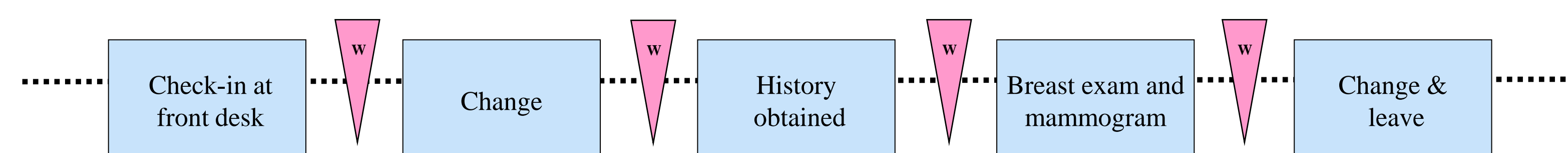
Activities that take time, resources, or space but do not provide any value to the customer, such as *searching for information*

Courtesy of Suneja A and Suneja, C. Lean Doctors.

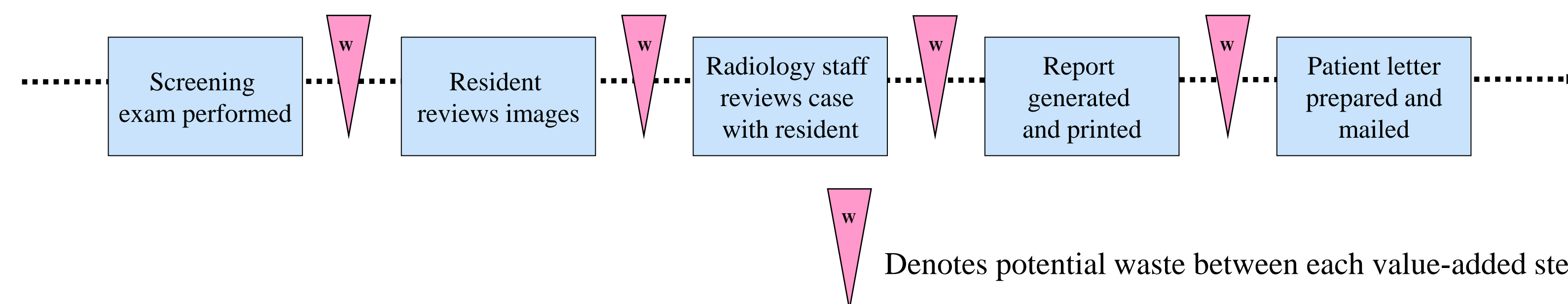
Each value-added step, defined as moments in the overall experience which the patient actually cares about, is documented as a box along the stream. It is between these boxes, or value-added steps, that the majority of non-value added activities or wastes within a given system can be identified. These wastes take up time, resources, and/or space without providing value to the patient.

Sample value stream maps below illustrate the steps taken by a patient undergoing screening mammography, from the time of check-in to check-out, as well as the screening mammography reporting process, from the time the images are acquired until the final report and patient lay letter are sent.

Screening Mammogram Patient Flow Process



Screening Mammogram Reporting Process



Lean Tools: "Waste Walk"

A fundamental Lean principle is direct observation of processes where they occur ("going to the gemba") in order to identify sources of inefficiency. As an application of this principle, a "waste walk" was performed within the breast imaging department. During this exercise, team members silently observed normal workflows by shadowing patients from check-in to check-out, technologists from start of exam to end of exam, and physicians as they read the screening mammograms. Wastes were identified in seven defined categories.

Waste Category	Defined As	Observed Examples
Motion	Unnecessary movement of staff or patients	Technologists searching for available rooms Staff searching for materials Staff attempting to locate physicians or other staff Staff walking to collect printed materials
Transportation	Unnecessary movement of equipment	Moving film jackets to the reading room to be read Hanging hard-copy prior films Returning and filing film jacket once a study was read
Inventory	Supplies, too much or too little	All necessary forms not available at each reading room workstation Staff leaving exam room in search for supplies Some supplies kept in exam room are rarely used
Waiting	Delays for patients or staff	Patient waiting in lobby after check in Patient waiting in changing waiting room while technologist prepares exam room Technologist waiting for patient to change Resident waiting for batch of studies to be brought to reading room Resident waiting to staff with attending as staff-out time is not standard
Defects	Errors or flaws in the system	Screening patient turned diagnostic and additional imaging and/or procedures necessary that were not scheduled Tedious computer system with multiple technical glitches
Over-processing	Work or role not clearly defined	Technologists having patient switch rooms because the one they are in does not have all necessary equipment Multiple computer systems and logons required by the technologist to complete one study Radiologists pulling digital comparisons from PACS to workstation
Over-production	Excess work that does not add value	Maintaining patient log on clipboard by technologists and radiologists

Use of Lean Principles to Improve Efficiency of Screening Mammography Workflows in an Academic Institution

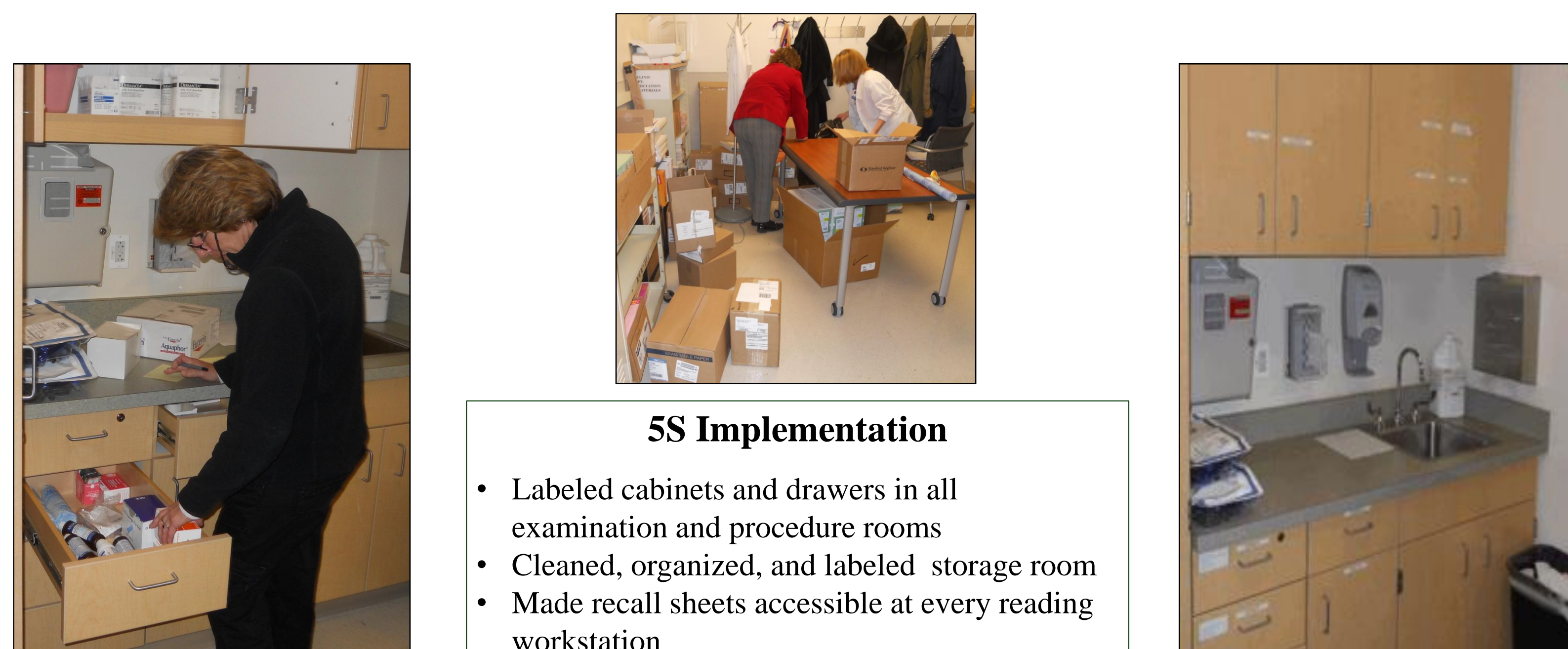
C J Shah, MD, Milwaukee, WI; J R Sullivan, MD; M Gonyo, MD; A Wadhwa, MD; M DuBois, MD; K A Shaffer, MD; M Wein, MD; J Youker, MD

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Lean Tools: Five S

The Lean tool Five-S focuses on enhancing visual order and organization in the workplace in order to optimize efficiency.

- Sort:** Retain necessary items and remove unnecessary items
- Straighten:** Organize and arrange items in easily accessible locations
- Shine:** Keep working areas and equipment clean and well-maintained
- Systematize:** Design a system to maintain the implemented order
- Sustain:** Continuous up-keep requiring self-discipline not to slide back into former state



5S Implementation

- Labeled cabinets and drawers in all examination and procedure rooms
- Cleaned, organized, and labeled storage room
- Made recall sheets accessible at every reading workstation
- Removed unnecessary supplies and clutter throughout the department

Lean Tools: Visual Communication

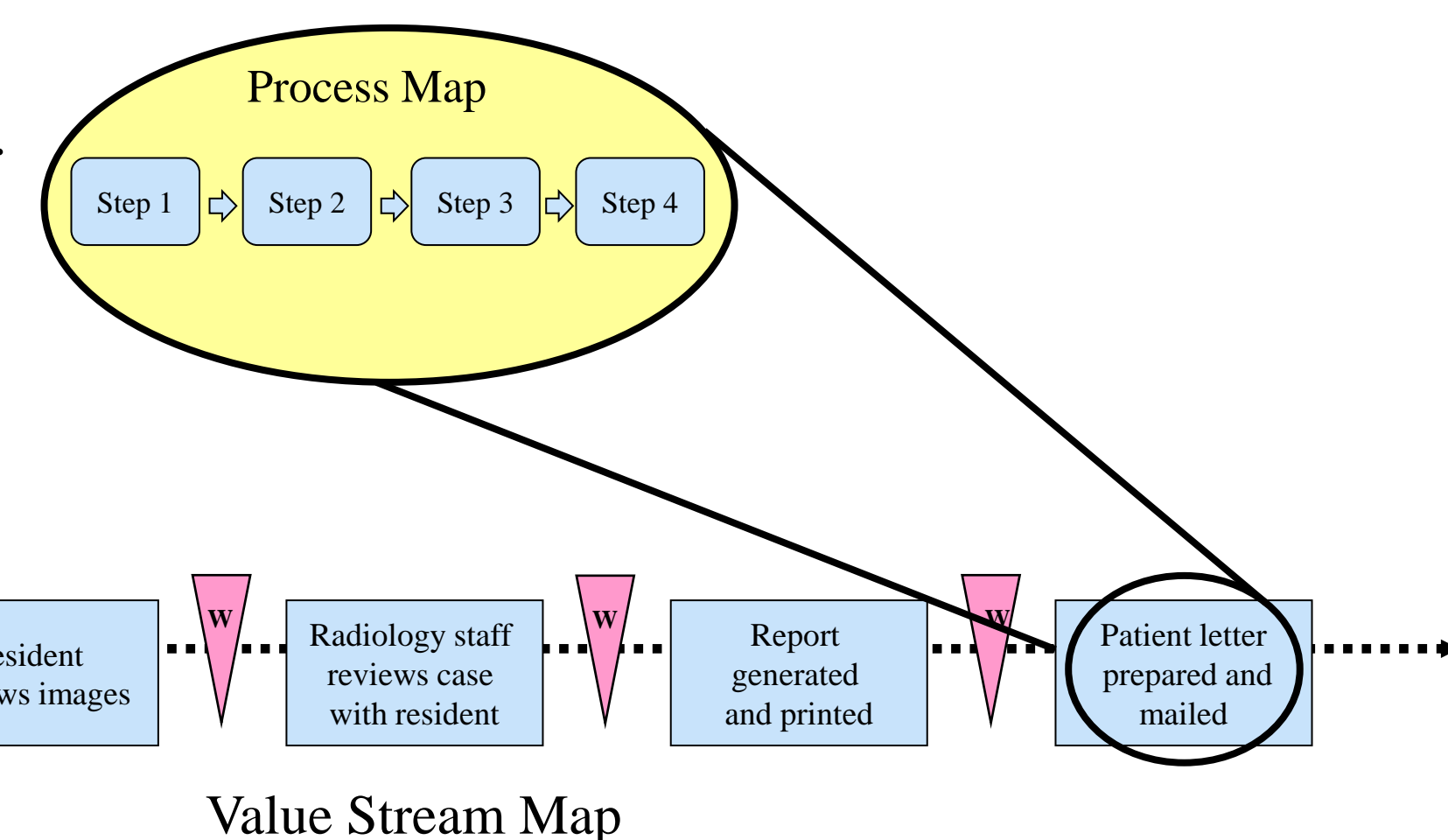
Visual communication is a key component to the Lean process. Valuable information is displayed in a common place visible to all staff members. This information allows staff members to know where to go or what to do next without the need for verbal communication that might interrupt another person's workflow.

Benefits of Visual Communication

- Information shared with people who can make a real-time difference in outcome
 - Same information available to everyone, no matter an individual's role or place within the system as a whole
 - Promotes an environment of self-service, in which staff can access information needed at any given moment in order to make a decision
 - Everyone on the team knows how their role fits into the overall process and that their actions and tasks have meaning
 - Designed to be visible from long distances, which saves wasted motion for all staff
- Courtesy of Suneja A and Suneja, C. Lean Doctors.

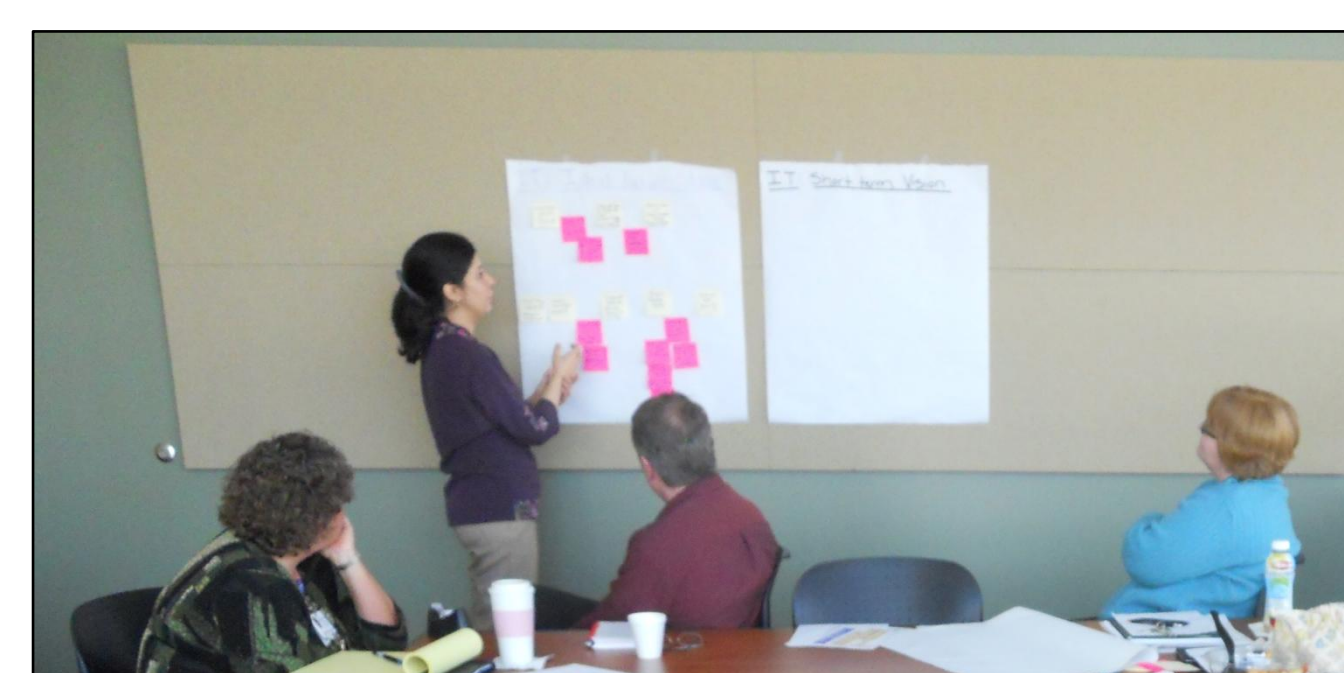
Lean Tools: Process Map

A **process map** begins with the value stream map and breaks down each value-added step into smaller, more detailed steps. This often-lengthy map defines exactly what needs to be done for each step to be completed and who is responsible. Clearly defining this process allows for increased awareness of the overall process, identification of potential bottlenecks in flow, and insight into potential wastes.

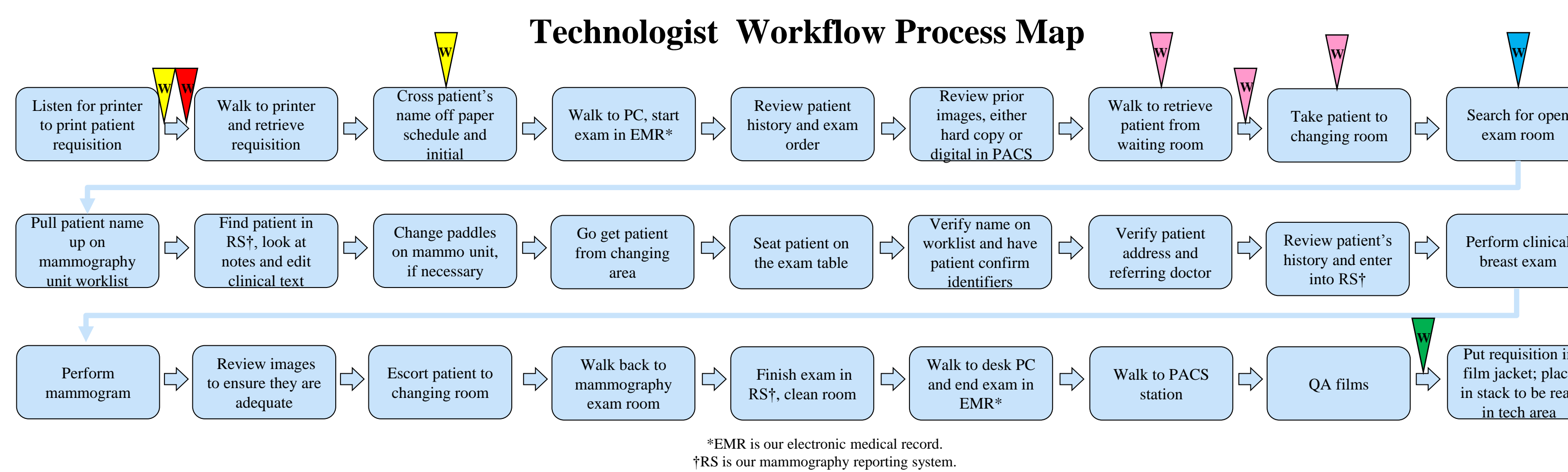


Applying Lean Tools to Our Practice

Once we became familiar with these Lean tools, we began applying them to our practice. Each step of our screening mammography workflow was scrutinized with process maps, and additional wastes were identified. The team then worked together to generate potential solutions to decrease or eliminate these wastes, and trials were performed to test these solutions.



Although many wastes were identified in this process, only those wastes for which solutions were trialed are marked with a color-coded "W" and discussed below the applicable process map.



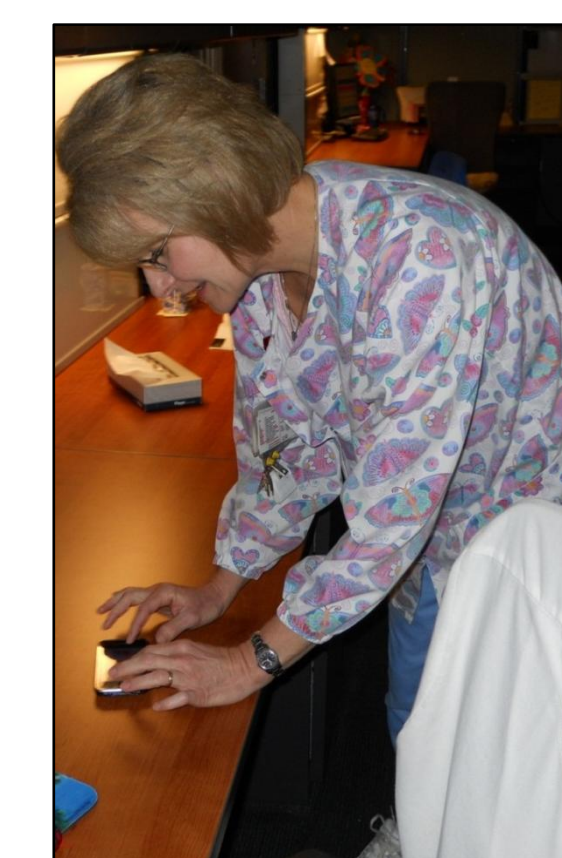
Lead Tech Trial

Prior to this trial, the technologists would listen for a paper requisition to print which would notify them that a patient had checked in for her exam. Several technologists would hear the printer print and walk over to see which patient had checked in. Then, the technologists would have to decide who was going to perform the exam. Also, a technologist sitting far from the printer may not hear the requisition print.

In an attempt to minimize these wastes of motion and over processing, we trialed a workflow in which one technologist was named the lead technologist for the day. The lead technologist sat near the printer and monitored for checked-in patients. Then, she assigned each patient to the next available technologist.

Portable Electronic Device Trial

Technologists walk to the printer to retrieve the paper requisition form. This is a waste of motion, not to mention a tangible waste of paper.



In an attempt to eliminate these wastes, a paperless workflow using portable electronic devices was trialed. Instead of relying on the paper requisition, the technologist carried an electronic mobile device with them to verify patient information. Both an electronic tablet and a smart phone were trialed for this purpose.

Patient Wait Times Trial

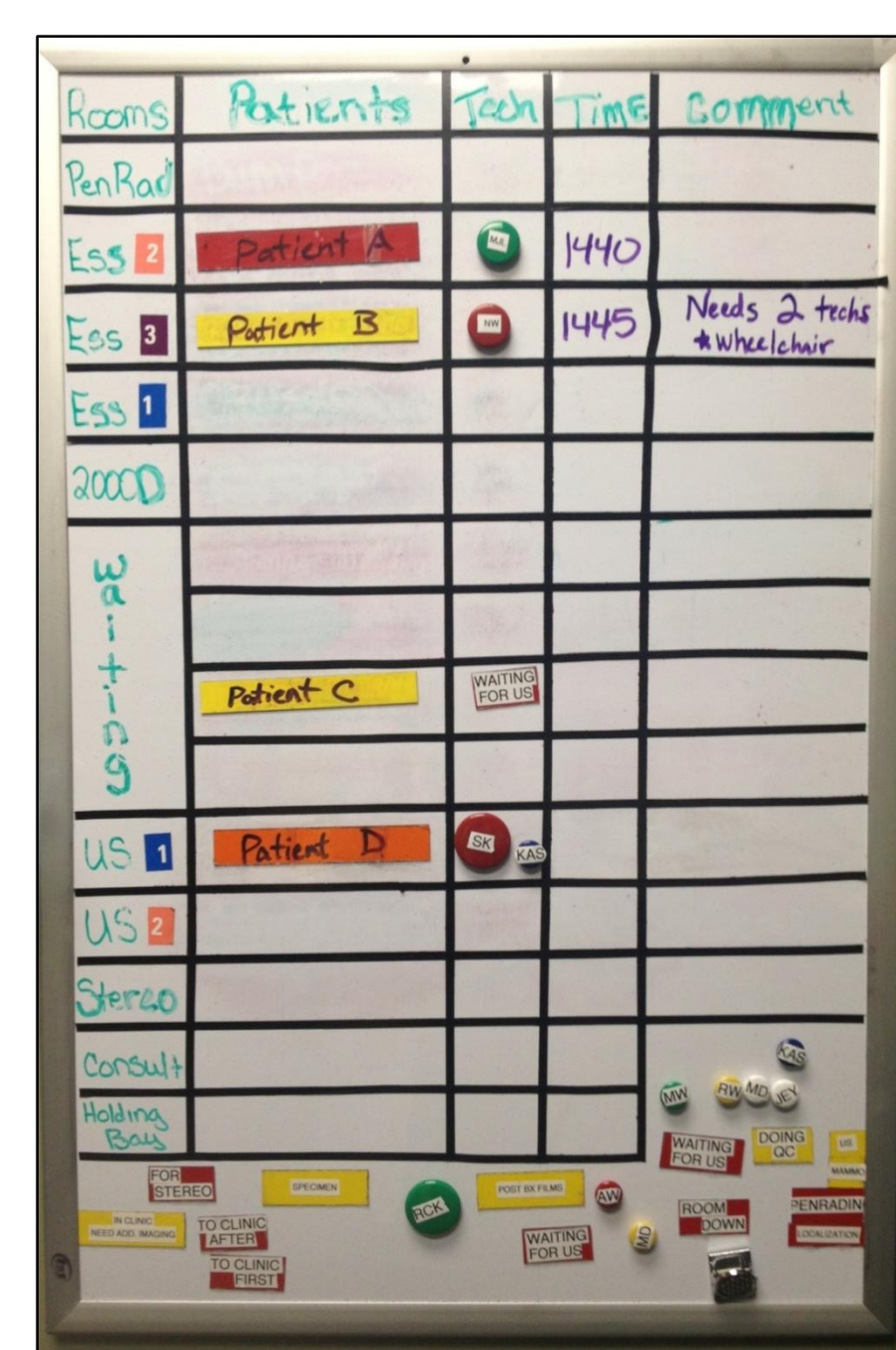
Prior to this trial, the technologist would greet the patient in the waiting room and escort her to the changing room. While the patient was changing, the technologist would search for an open mammography exam room and prepare the exam room. This often led to either the patient waiting for the technologist or vice versa.

A trial was created utilizing an aide to greet the patient and escort her to the changing room and changing room waiting area. This allowed time for the technologists to prepare the mammography exam room and then greet the patient in the changing room waiting area. Patient wait times before and during this trial were recorded.

Visual Communication Trial: Technologist White Board

To eliminate the waste of searching for an open exam room, a large dry erase white board was created to track the availability of the exam rooms. The lead technologist used this white board to determine which exam room should be used for the next patient. This white board included a column to denote the time an exam started, which allowed the lead technologist, and everyone else, to anticipate when rooms might become available. A smaller dry erase white board was created to keep track of which technologists are working and who is next in line to take a patient.

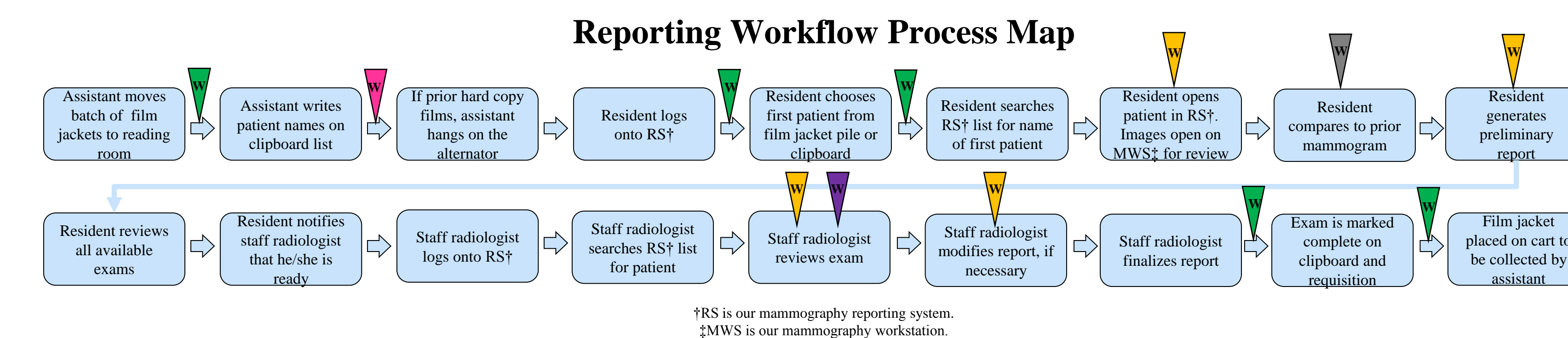
The layout and content of this board evolved since its initial implementation. These changes were driven by suggestions from the technologists themselves.



Technologist White Board

- Demonstrates which exam rooms are available
- Shows what procedure rooms are in use
- Tracks where patients are located
- Time column enables technologists to estimate when patients or rooms may be available
- Technologist "batting order" creates a more even distribution of work

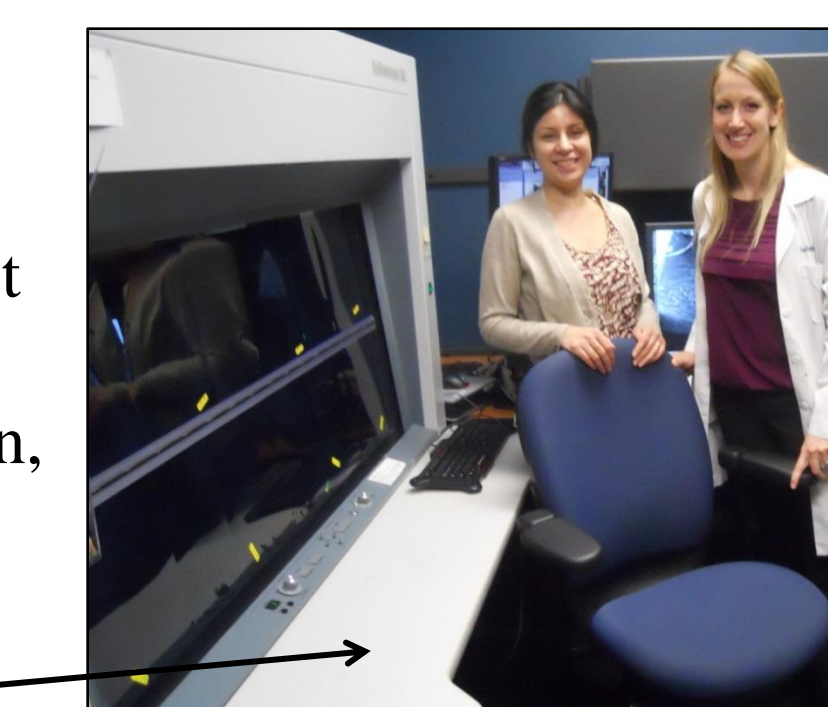
Please refer to **Electronic Worklist Trial** in next section.



Electronic Worklist Trial

In order to combat the wasted motion, transportation, and over processing of this clipboard based reading workflow, screening mammogram studies without a comparison or with digital comparisons were set to a specific status on the worklist ("AutoTrack") by the technologist upon termination of the exam. This status indicated that the study is available for review without requiring a paper requisition, film jacket, or clipboard or searching for the patient name on the RS (reporting system).

This counter space used to be covered with film jackets containing patient requisition forms and the clipboard used to keep track of screening studies to be read.



Digitizer Trial

The wasted time, motion, and transportation of hanging hard copy comparison films on the alternator was eliminated when the section purchased a digitizer. In anticipation of the upcoming screening mammogram appointments, an aide digitized prior hard copy films before the patients arrived. If the patient arrived with hard copy images from an outside institution, these films were digitized before the exam was made available for the radiologists to read.

Redefining Roles Trial

Because of limited local memory on our mammography workstations (MWS), older studies often drop off of the workstation, an inconvenience that requires the radiologist to search for the studies on PACS and pull the images to the reading workstation, wasting radiologist reading time. A new role for the assistants was trialed in which they previewed the exams and ensured that all necessary studies were available on the workstation prior to placing the exam on the worklist as ready to review. However, it soon became apparent that this was only a temporary solution to a much larger problem.

Evaluation of Information Technology Systems

We use four separate information technology systems for mammography interpretation (ie, mammography reporting system (RS) distinct from the electronic medical record (EMR), and image display system (MWS) separate from image storage system (PACS)), resulting in problematic system interfaces. The radiologist must navigate between these separate systems to access all images and information necessary to interpret the study. For example, limited clinical information is available in the RS which requires the radiologist to access the EMR with a separate log-in in order to access additional clinical information.

In addition, inefficiencies with our current RS have been identified, as report creation requires significant editing by the radiologists.

As it became evident that our information technology systems were crucial contributors to the inefficiencies of our section, major investigations of the MWS and RS were launched. Working in conjunction with specialists from clinical imaging, we organized demonstrations of two mammography workstation vendors (an upgraded version of our current MWS and a mammography module in our department-wide PACS). A similar trial is in process for our reporting system.

Visual Communication Trial: Physician White Board

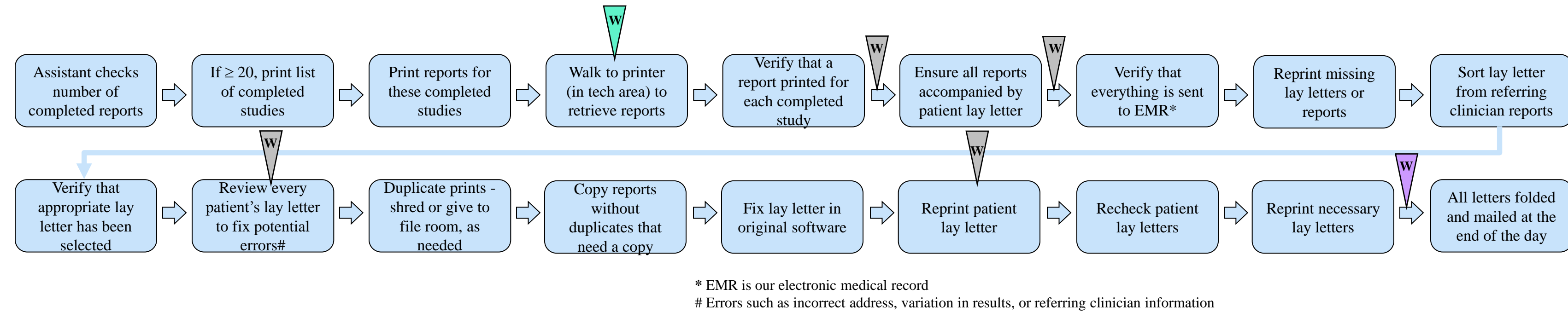
The staff radiologist would be interrupted several times during review of cases with the resident. Often, these interruptions were technologists who were looking for the staff radiologist assigned to diagnostic mammography. To minimize these interruptions, a dry erase white board was created which displayed the location of all radiologists in the section. It was each radiologist's responsibility to move his/her magnet whenever he/she changed location. This board also displayed a list of procedures and meetings.



Physician White Board

- Denotes physicians working in the department for the day
- Clarifies staff assignment (screening, clinic, or diagnostic)
- Specifies which reading room and workstation staff are working from
- Tracks physician whereabouts (at workstation, in ultrasound, performing a procedure, or temporarily out of the department)

Generating Reports & Mailing Lay Letters Process Map



Printer Relocation

Walking to the printer is a waste of motion for the assistant. A printer was moved to her office so she would no longer have to walk to the technologist work area to retrieve the printed reports.

Report Printing Trial

Currently, our finalized reports must be manually committed in the RS before they are sent to the EMR for the referring clinicians to see. The reports and accompanying lay letters are then reviewed by the assistant for errors, such as incorrect patient address, incorrect ordering physician information, or missing patient lay letter. The assistant may also need to edit an individual patient letter because the desired message communicated to the patient is not represented in the current letter templates.

A trial in which the printing process was observed outlined the type of errors that occurred and their frequency. The need to customize the wording of an individual patient's letter was found to be the most common problem encountered by the assistant. This led us to embark on a project to revise our patient letters, using data from this trial (which are the most common letters to be edited) to guide us.

Also, the information technology department, EMR and RS were made aware of the demographic glitches in the process and are currently in the process of resolving these issues.

Lay Letter Mailing Trial

Previously, all lay letters were folded and mailed at the end of each day. With this workflow, the lay letter for a report completed in the evening would not be mailed until the following afternoon. In order to reduce patient result wait times, a trial was proposed in which all lay letters were folded and mailed earlier in the day. This would allow patients whose reports were completed in the evening and early morning to receive their results one day sooner.

RESULTS

Decreased Patient Wait Times

- Prior to the **Patient Wait Times Trial**, the average total wait time for a screening mammography patient was 11.1 minutes.
- After the trial, the average total wait time for a screening mammography patient was reduced to 3.3 minutes.
- Overall patient wait time decreased by 70%.**

	Pre-trial	Post-trial
Patient Average Wait Time	11.1 min	3.3 min
Patient Total Service Time*	13 – 35 min	17 – 28 min
Patient Total Visit Length	15 – 64 min	18 – 33 min

*Service time denotes value-added time, meaning actual time the patient spent with the technologist and/or radiologist.

- Also, the **Technologist White Board Trial** has allowed us to monitor patients' whereabouts and wait times.

Improved Efficiency of the Technologists

- The **Technologist and Physician White Board Trials** and **Lead Technologist Trial** have improved efficiency of the technologists.
 - The white boards have saved wasted time and motion searching for available exam rooms and radiologists.
 - A more equal distribution of work with a "batting order" and direction from the lead technologist have encouraged productivity and improved morale.
 - Displaying the exam start time on the technologist white board enabled the lead technologist to anticipate when a room may be ready for the next patient and monitor patient status in the department.
- The use of an aide in the **Patient Wait Times Trial** provided the technologist with additional time to prepare the exam room and decreased wasted motion.
- The use of a portable electronic device by the technologists was not adopted following the **Portable Electronic Device Trial**, as it was not found to improve efficiency.

Improved Efficiency of the Radiologists

- With the implementation of the **Electronic Worklist Trial** and **Redefining Roles Trial**, staff radiologist read times for screening mammography decreased from 4.8 minutes per case to 2.9 minutes per case.

Average Radiologist Read Times	Pre-trial	Post-trial
Resident Preliminary Report	3.7 min	3.8 min
Staff Radiologist Final Report	4.8 min	2.9 min

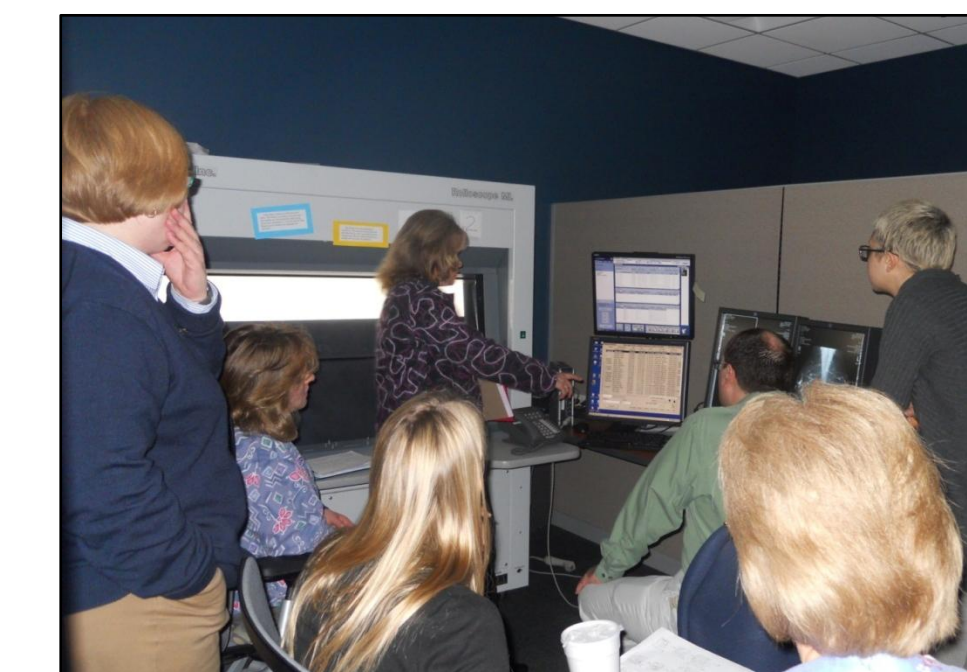
- This increase in efficiency has provided the radiologists with more time to teach fellows, residents, and medical students and has enabled the radiologists to devote more time to other modalities in breast imaging.
- The **Digitizer Trial** led to a more seamless comparison to prior studies and a tidier workspace for the radiologists.
- The **Physician White Board Trial** minimized interruptions of the radiologists.

Improved Report Turnaround

- The **Electronic Worklist Trial** has permitted a faster result turnaround time. By signifying which exams are ready to read on the RS worklist, the resident/radiologist no longer has to wait for the assistant to bring a batch of paper exam requisitions to the reading room.
- The **Digitizer Trial** has allowed for exams to be read without waiting for an assistant to hang the hard copy prior studies in the reading room.
- With implementation of the **Lay Letter Mailing Trial**, it is estimated that 5,000 patients each year will be receiving their results letter one day earlier.

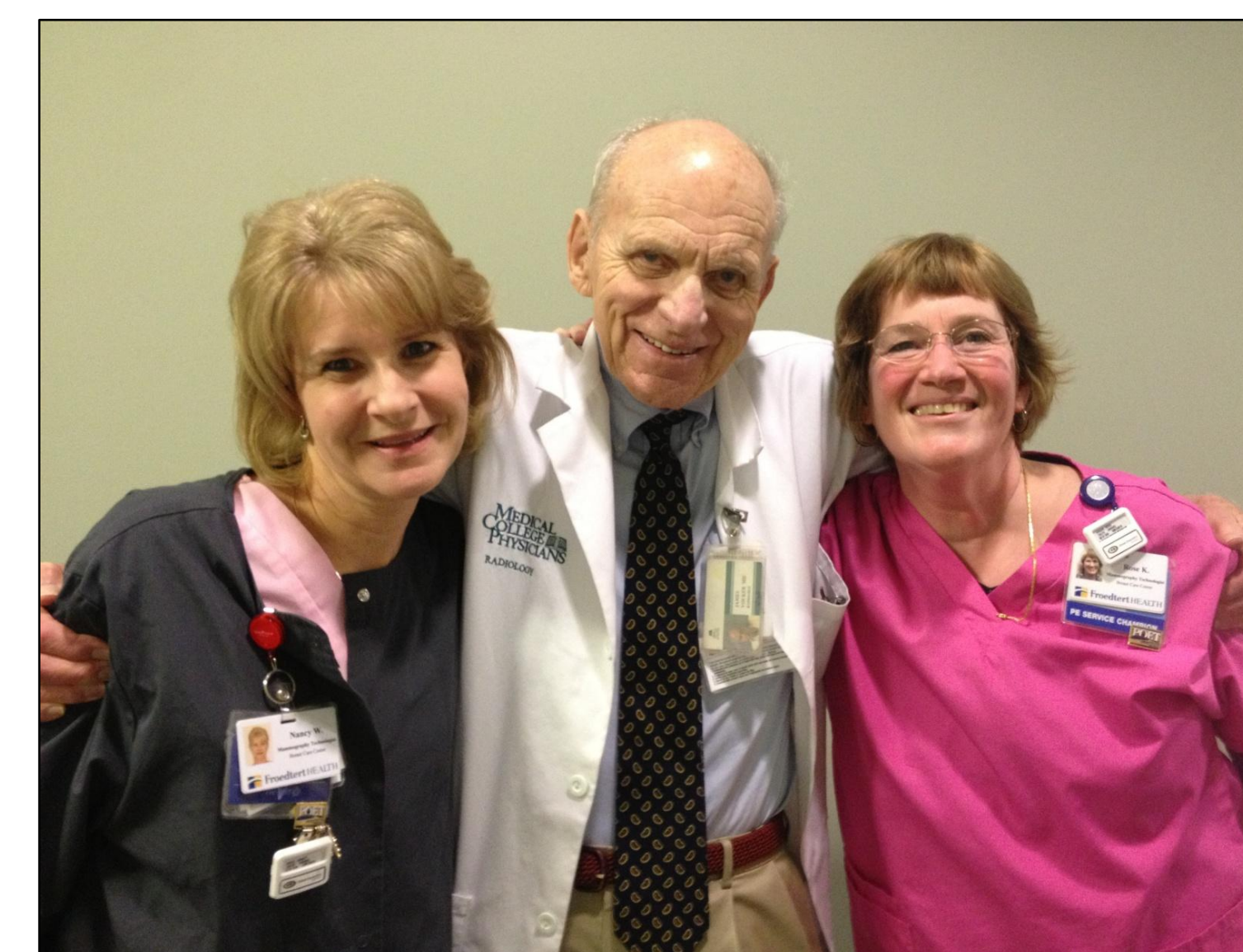
Continued Evaluation of Information Technology Systems

- Many sources of inefficiency in our MWS and RS, and their integration with the departmental PACS and EMR, were uncovered by this project. With the help of the clinical imaging section, investigations of both of these systems were launched to determine if improvements in the existing systems could be made or if alternatives were necessary.
 - After intensive analysis, we have decided to transition to a PACS-based workstation.
 - A major investigation of our current reporting systems is ongoing, and alternate reporting systems are being evaluated.



Additional Benefits

- The aide assigned to help patients change for their exams as part of the **Patient Wait Times Trial** reported increased job satisfaction, as she was able to experience direct patient contact.
- Addition of a printer to the assistant's office in the **Printer Relocation Trial** has simplified her workflow.
- Overall, the technologists reported feeling less stressed because of a more predictable, organized and equitable distribution of work.
- Clinicians from the adjacent Breast Care Center adopted use of the physician white board to help them locate a specific radiologist in the section.
- A more cohesive work environment developed.



CONCLUSION

The application of Lean principles to our screening mammography workflow has improved the efficiency of our section, while increasing the value added time for our patients. The workflow changes made were not just trialed and forgotten. Those that were found to favorably impact efficiency were immediately implemented section-wide.

Adoption of Lean has provided the structure, individualization and engagement of personnel for quality improvement that no outside consultant has been able to deliver. It has evoked a culture change in our section where equal involvement of all staff as agents of change, respect of all members' opinions, and openness to new ideas is fostered. Section members have come to see the importance of direct observation to fully understand a process and offer solutions to problems and the power of data-based decision making.

Addressing screening mammography workflows is only the starting point for improving the efficiency of our section. Now that we have learned the principles of Lean and recognized the benefits gained by their adoption for our patients, our productivity, and our job satisfaction, we can use these successes as a springboard for future quality improvements.

Future Directions

- Replace dry erase white boards with electronic monitors for visual communication
- Transition to PACS-based workstation
- Continue evaluation of mammography reporting and dictation systems
- Simplify patient lay letter editing process
- Extension of Lean principles to diagnostic mammography and ultrasound workflows
- Revision of daily exam schedule

References:

Kruskla JB, Reedy A, Pascal L, Rosen MP, Boieselle PM. Quality Initiatives Lean Approach to Improving Performance and Efficiency in a Radiology Department. *RadioGraphics* 2012; 32:573-587.

Suneja A and Suneja C. *Lean Doctors: A Bold and Practical Guide to Using Lean Principles to Transform Healthcare Systems One Doctor at a Time*. ASQ Quality Press, 2010.

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