## Pre-and Post-Analytical Stages: Why its Time to Use Performance Improvement Methods to Reduce Errors and Raise the Quality of Lab Testing

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Dept Laboratory Medicine

University of Washington



## Acknowledgements

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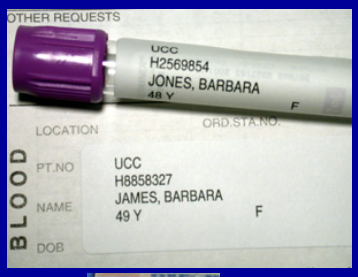
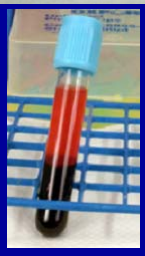
## Overview

- Preanalytic errors, Post analytic errors
- Current  approaches to lab quality
- What can Industrial Engineers do for labs?
- Sample projects
- Neglected patient safety issues
- Conclusions

## Preanalytic errors

- ❑ Requisition incorrect
- ❑ Specimen unlabeled, mislabeled, illegible (includes swapped labels)
- ❑ Failure to collect a specimen
- ❑ Wrong container
- ❑ Specimen suboptimal or ruined (clotted, hemolyzed, QNS…)
- ❑ Specimen lost or delayed
- ❑ Other specimen transport error
- ❑ Data entry error during accessioning of requisition (e.g., wrong patient, wrong test)
- ❑ Specimen processing error (e.g. aliquot labeling error)



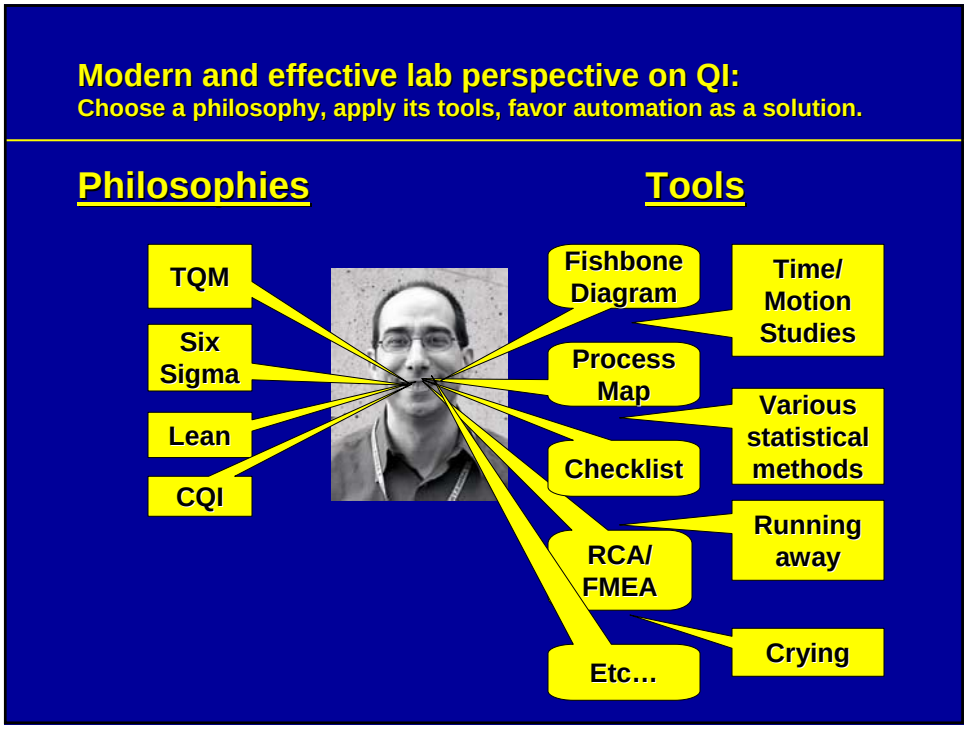
Mislabel (upper), sub optimal specimen (lower, right)

## Postanalytic errors include 1 or more of the following:

- ❑ Postanalytic data entry error
- ❑ Oral miscommunication of results
- ❑ Error in reporting to downstream printer, fax, or electronic medical record (EMR)
- ❑ Physician or other provider fails to retrieve test result
- ❑ Failure to communicate critical value
- ❑ Provider misinterprets lab result
- ❑ Others

## Old-fashioned view on QI

- Errors are mainly caused by incompetence,  or impairment
- QI consists of having backbone
- Blame_Shame_Train is the focus
- Still a common view because incompetence sometimes a factor in harm-causing errors.




**Dear Mike,** Thanks for telling us about Lean. We are saving paper by not using any margins. We are all drinking milk directly from our cartons. Even though this is disgusting, we have reduced the number of milk pouring errors dramatically, as well as the wasted time of washing, and sometimes breaking dishes. Also, we are all wearing our pajamas to work and changing our underwear every other day. By increasing our underwear maintenance interval we are saving lots of time, and we are still well within most people's smell tolerance, although on one hot day in the summer, we had a variance and it got very ripe in the laboratory.Thanks for being such a great consultant. **Sincerely**, The idiots who took a great philosophy like LEAN and ruined it.

## Principles of Toyota/Lean Production Systems

**Flow** Work should *move* through the organization *without interruption.*

- Single piece flow.
- Value-Stream Maps are used to document as-is and define future state.

**Pull** *Link* value-added activities, in a cascade fashion, to *client demand*.

- Signals from clients should drive operations (pneumatic tubes are signals to do work; courier ops push not pull)

**Improve** *Everyone* strives to *reduce waste* and *achieve excellence*.

- Value is defined by your Customer, not from the standpoint of your department or organization.
- Kaizen events are used to make *incremental* improvements (move towards future state)

### Common Types of Preanalytic Waste in Clinical Labs

| | |
|---|---|
| **Delays /Waiting** | **•Batching (e.g., in AM inpatient phlebotomy)<br>•Delays related to using serum rather than plasma<br>•Delays (e.g., transport delays) between test order and sample draw, draw and arrival in lab, receipt in lab and specimen processing, processing and analysis** |
| **Duplication** | **Duplicate specimen collection and test orders** |
| **Correction/ Rework** | **•Redraw due to suboptimal specimens (e.g., line contamination, hemolysis, QNS, clot, wrong temperature)<br>•Redraw due to mislabeling** |
| **Motion/Steps** | **Positioning common analyzers far from processing<br>Materials for processing placed too far from techs** |
| **Inventory mismanagement** | **Insufficient inventory or too much inventory (e.g. labels)** |

Modified from reference 2.

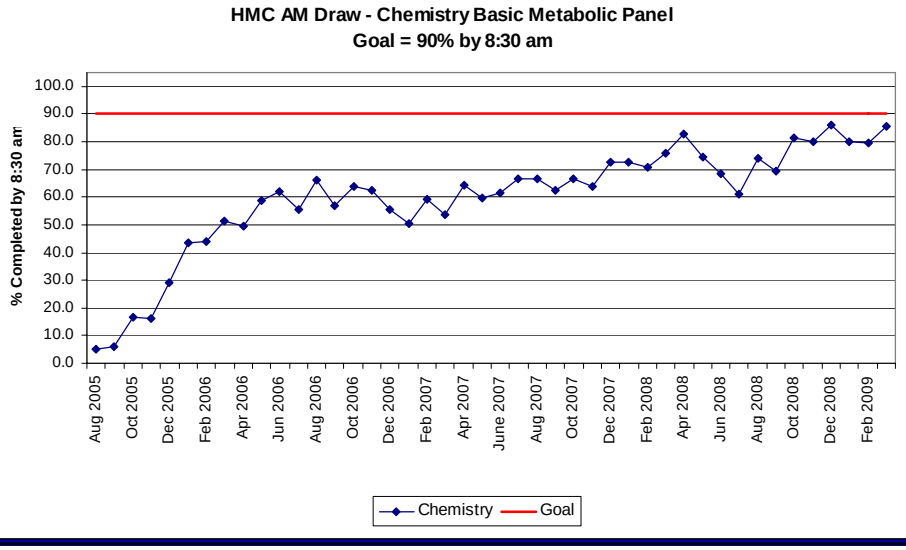
**Engineers in the Clinical Laboratory. Clin Lab News. Jan, 2009**
**www.aacc.org/publications/cln/2009/january/Pages/safety2Jan09.aspx**

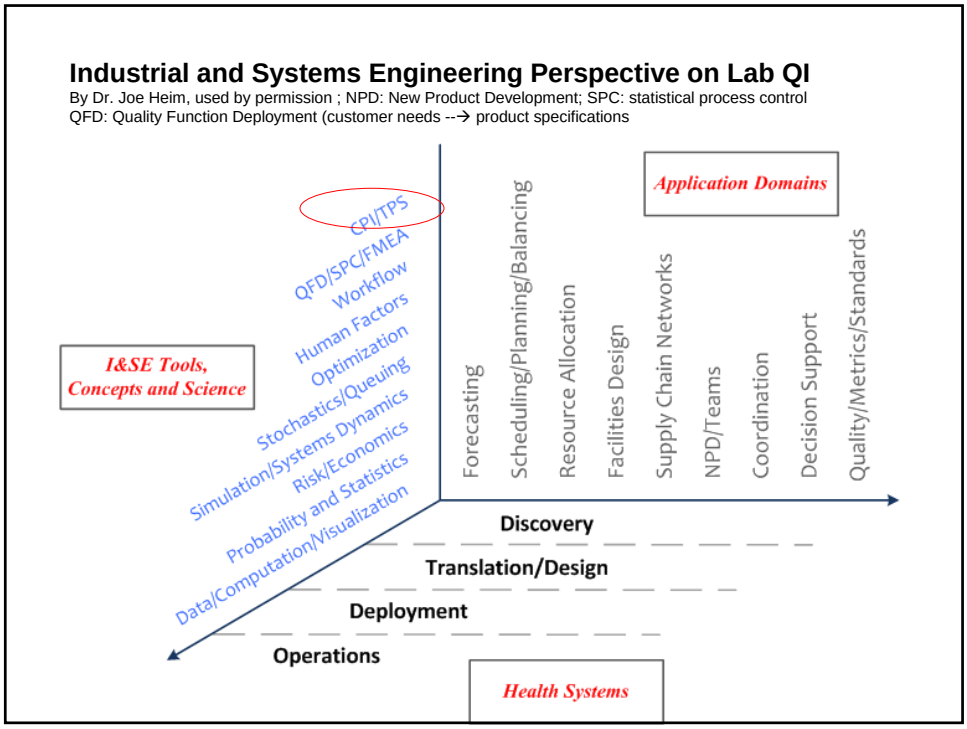
## Lean example:
## Decreasing delays (waste) in AM test results by reducing batch sizes in AM blood draw

- Start morning blood draw earlier
- Send specimens to lab after each draw, no batching
- An early Lean project starting Aug 2005

Phlebotomist arriving with big bag of specimens that will cause backup in processing.

## Quality Dashboard: Inpatients
## % AM results available by AM rounds



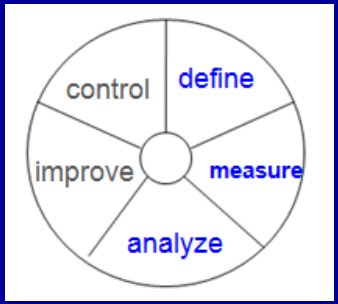



**Project: Gaining quantitative control over specimen collection, transportation and processing**

- **Start of project:**
  - **Had just completed TLA at 2 hospitals**
  - **Started looking at specimen processing. Questions without answers...**
    - **Why is error rate for manual entry of requisition into the LIS so high (about 2%)?**
    - **What quality metrics are being monitored?**
    - **Is there evidence we need more FTE?**

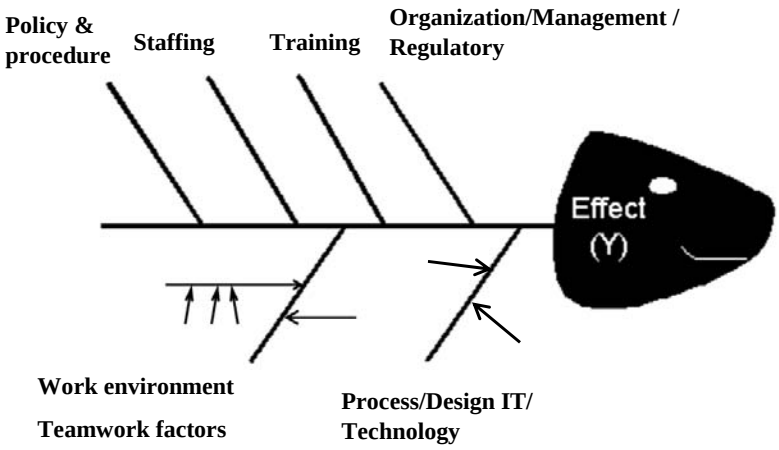
## Started by defining the state of the division

- **Root Cause Analysis**
- **Defining a Quality Dashboard**
- **DMAIC framework**

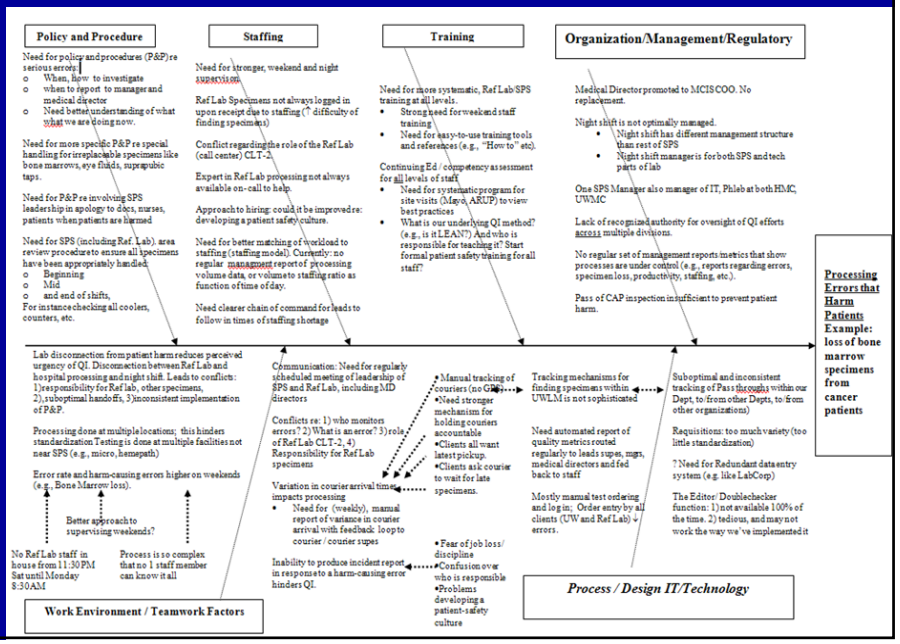



## RCA:Cause and Effect Diagram:

Potential contributing factors to serious processing errors



## RCA suggests deep problems




## Quality Dashboard: Current State (2010)

**Phlebotomy**
- % AM results available by rounds
- Productivity per FTE
- Error rates (mislabel, wrong tube, contamination rate)
- Relabel rate

**Couriers:**
- arrival time
- missing data re arrival time

**Call Ctr:**
- Tally inbound and outbound calls
- time to 1st answer
- abandon call rate
- FTE: time logged into system

**Human Resources**
- Attendance
- Counseling status

**Finance ☺**
- Receipts per outside client
- 3rd party payer report card

- SPECIMEN PROCESSING……..

## Specimen Processing Quality Dashboard (2010)

- Tally of each type of work by shift.
  - Goals: Increase # of interfaced requisitions and apply special methods to highest risk work
- Workload as a function of time of day.
  - Goal: Workload leveling
- # Specimens processed per hour per FTE
  - Goal: work at 70 % to 80% of capacity
- **Log in error rate for each type of requisition
  - Goal: ↓ error rate for manual login to 3 per 1000 reqs
- Many others

## Processing: Logging Work Type by Shift – Hospital B

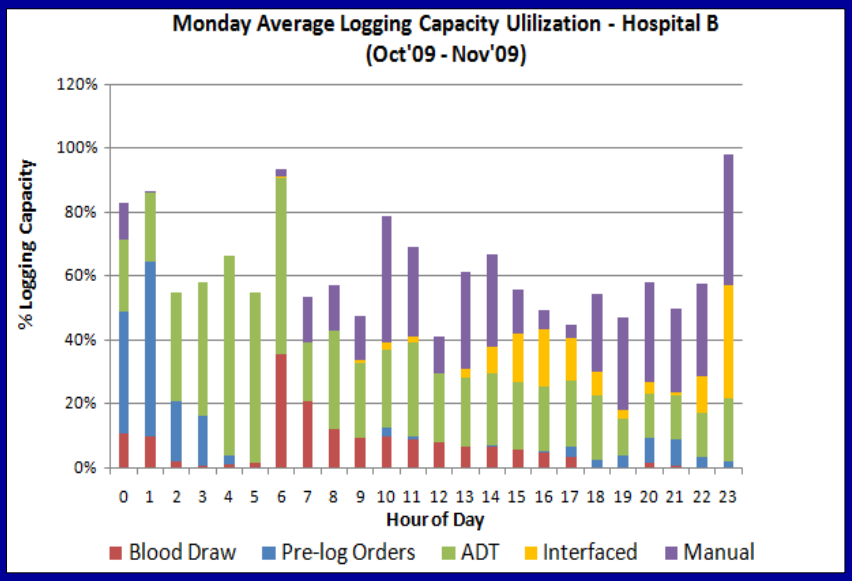
| | Weekdays | | | |
|---|---|---|---|---|
| | Data Range: 12/01/09 to 12/31/09 | | | |
| Shift | BD Check | IF | Partial IF | Manual |
| Midnight 0000-0800 | 144 | 44 | 272 | 19 |
| Day Shift 0800-1600 | 22 | 101 | 218 | 127 |
| Evening 1600-0000 | 13 | 164 | 199 | 126 |

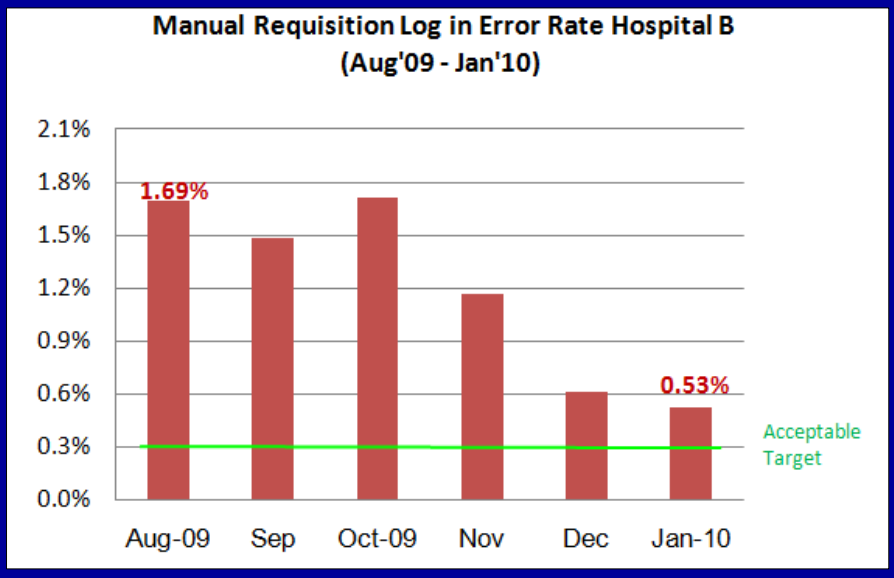
**272** high risk requisitions per weekday

| | Saturdays | | | |
|---|---|---|---|---|
| | Data Range: 12/01/09 to 12/31/09 | | | |
| Shift | BD Check | IF | Partial IF | Manual |
| Midnight 0000-0800 | 131 | 28 | 254 | 15 |
| Day Shift 0800-1600 | 11 | 1 | 136 | 45 |
| Evening 1600-0000 | 10 | 126 | 157 | 14 |

**73** high risk requisitions per Saturday

## Measuring Productivity of Specimen Processing



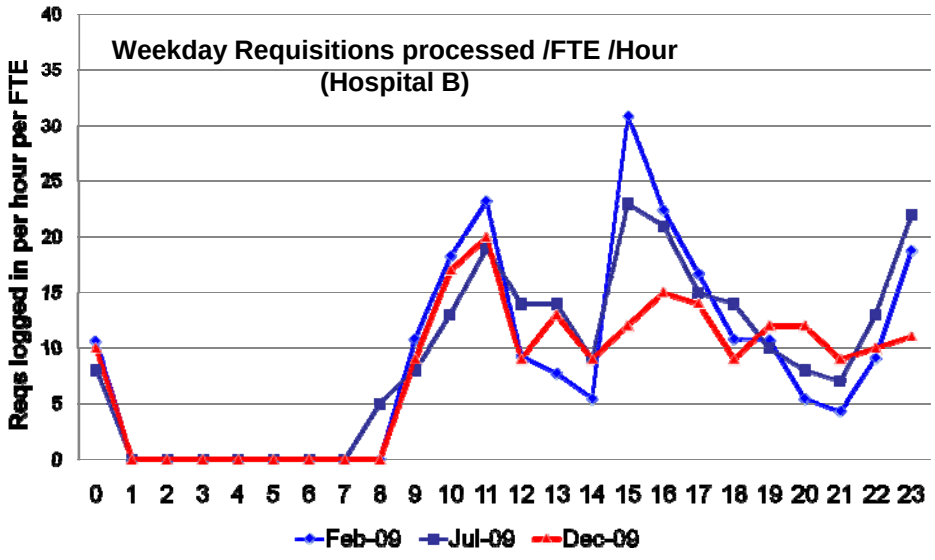



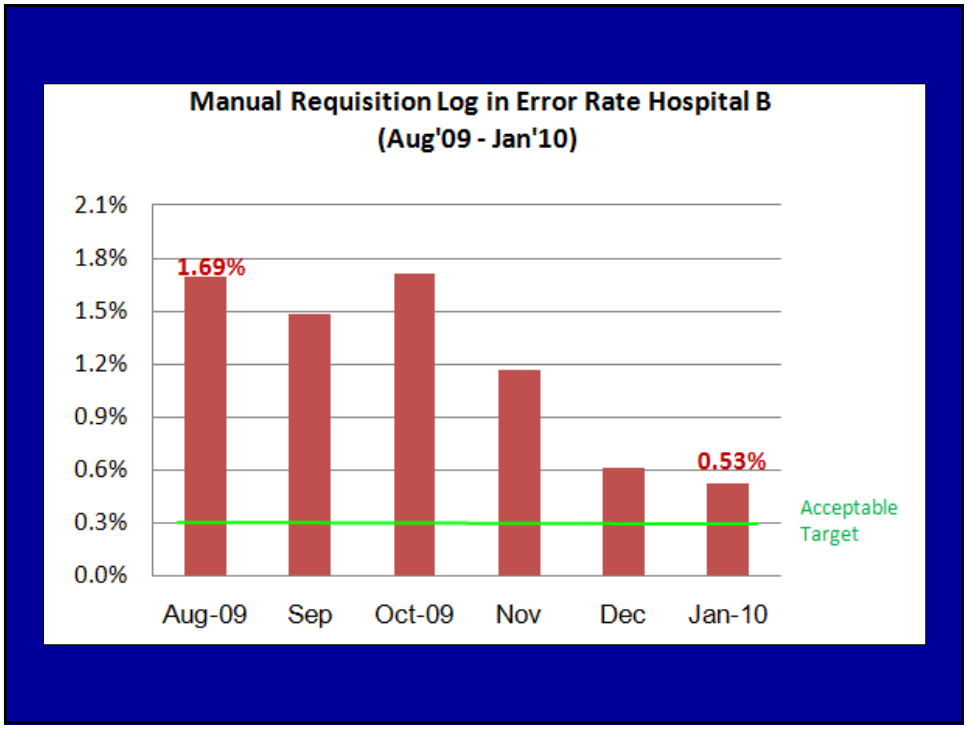
## Reducing errors in high risk work when work must remain manual

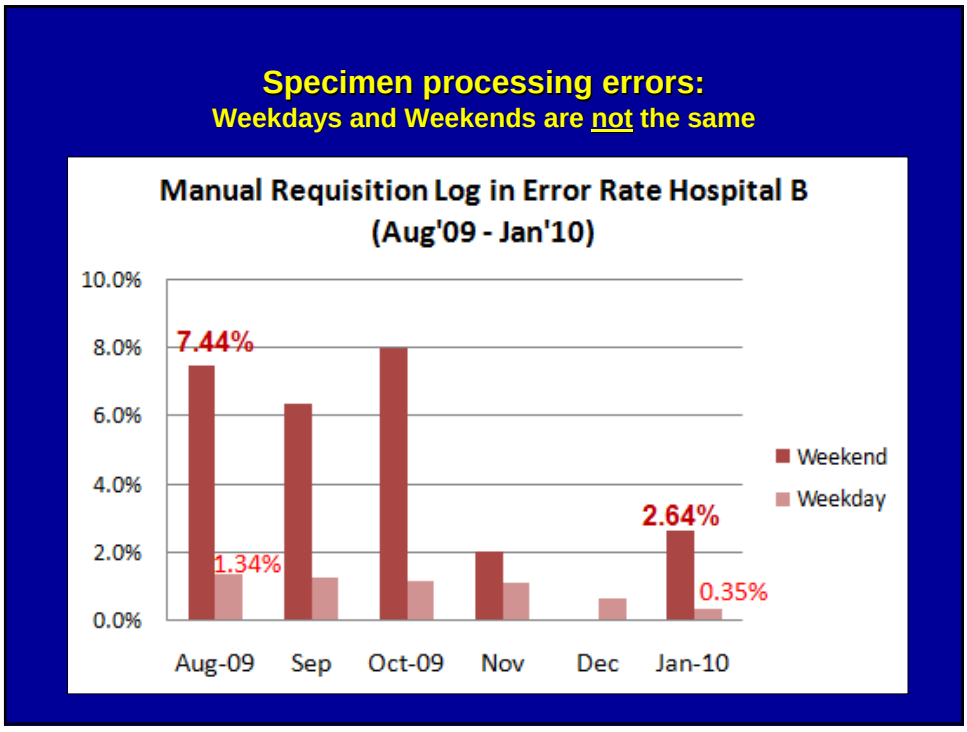
- Enhance supervision
- Isolate the high risk work (no multi tasking)
- Specialize the work to a small group of highly trained people who are tightly monitored.
- Standardize the work
- Remove time constraints from the group
- ↓ batch size, smooth work flow
- Consider double checking with accountability
- For data entry, use redundant entry if feasible

## Workload leveling in the Reference Lab

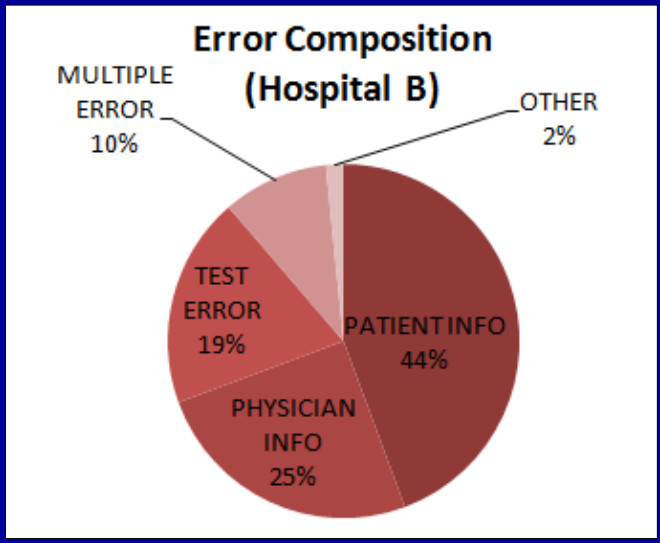
**(Adjusted courier routes; sorted and paced the work)**




Manual Requisition Log in Error Rate Hospital B
(Aug'09 - Jan'10)
2.1%
1.8%
1.5%
1.2%
0.9%
0.6%
0.3%
0.0%
1.69%
0.53%
Acceptable
Target
Aug-09
Sep
Oct-09
Nov
Dec
Jan-10

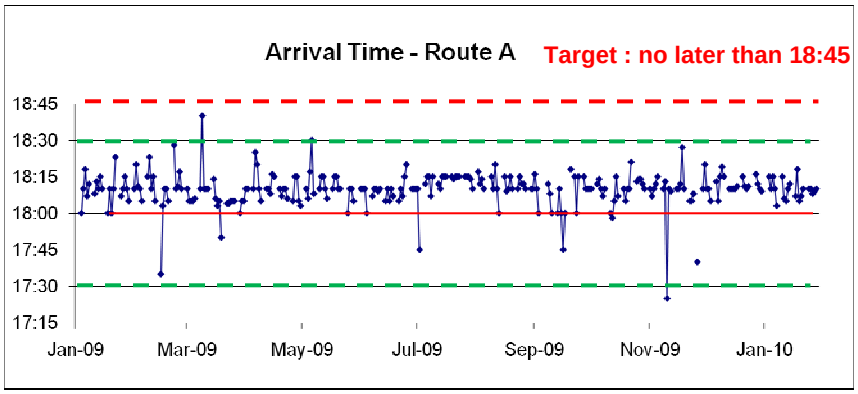

Specimen processing errors:
Weekdays and Weekends are not the same
Manual Requisition Log in Error Rate Hospital B
(Aug'09 - Jan'10)
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
7.44%
1.34%
2.64%
0.35%
Weekend
Weekday
Aug-09
Sep
Oct-09
Nov
Dec
Jan-10

## Specimen Processing Log in Errors




## Specimen Transportation

# Monthly Summary of Arrival Time: Route A




## Courier On Time Arrival at Hospital B: (Total 7 Routes Mar 09' – Jan 10')

| ROUTE | Mar-09 | Apr-09 | May-09 | Jun-09 | Jul-09 | Aug-09 | Sep-09 | Oct-09 | Nov-09 | Dec-09 | Jan-10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 95% | 100% | 95% | 95% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| B1 | na | na | na | 77% | 64% | 75% | 59% | 95% | 83% | 93% | 89% |
| B2 | 59% | 32% | 81% | 41% | 30% | 52% | 70% | 86% | 85% | 100% | 100% |
| C | 91% | 59% | 86% | 86% | 87% | 75% | 79% | 100% | 100% | 100% | 100% |
| D | 91% | 86% | 95% | 100% | 100% | 100% | 94% | 100% | 100% | 100% | 100% |
| E | 95% | 82% | 95% | 100% | 95% | 84% | 100% | 91% | 95% | 100% | 100% |
| Weekend | | | 80% | 100% | 100% | 100% | 100% | 100% | 75% | 100% | 100% |
| Weekend | | | 60% | 100% | 67% | 0% | 0% | 100% | 100% | 75% | 100% |
| H1 | | | | | 96% | 71% | 86% | 86% | 94% | 94% | 100% |
| H2 | | | | | 100% | 81% | 90% | 90% | 88% | 88% | 100% |
| H3 | | | | | 89% | 83% | 93% | 93% | 88% | 100% | 100% |
| H4 | | | | | 91% | *94%* | 94% | 94% | 91% | 100% | 100% |
| I1 | | | | | | | | | 100% | 100% | 100% |
| I2 | | | | | | | | | 100% | 94% | 100% |
| I3 | | | | | | | | | 75% | 100% | 100% |
| I4 | | | | | | | | | 11% | 100% | 100% |
| I5 | | | | | | | | | 6% | 100% | 100% |

# A3: A transportation model for couriers route planning

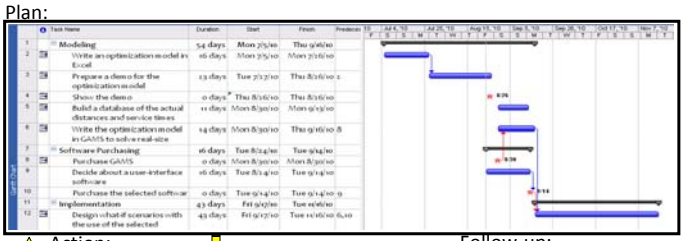
**Introduction:**

Basic Concept

The addresses and the time window of the clients → Driving Routes

The addresses and the time windows of the clients → Current Condition: Transp. Dep.

**Plan:**



**Action:**

- Create a database of the driving times and service times.
- Purchase the optimization software.

**Follow-up:**

- Weekly meetings with Dr. Heim.
- Biweekly fishbone meetings.

**Proposal**

| Client name | First time window | Second time window |
|---|---|---|
| SLU | 8:00 am | 3:00 pm |
| PAC Lab Bellevue | 8:11 am | 3:00 pm |
| Overlake Hospital | 8:30 am | 3:00 pm |
| UWPN-Eastside Specialty Clinic | 8:00 am | 3:00 pm |
| Eastgate UWMC Midwifery Clinic | 8: 00 am | 3:00 pm |
| UWPN-Issaquah | 8:00 am | 3:00 pm |

*** The driving distances between the clients are calculated before running the model.**

**Clients sequences in a sample proposed route**

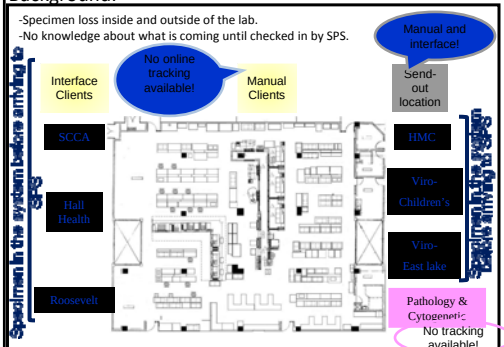
- The inputs are:
  - Clients locations
  - Clients time windows
  - Clients service times
- The output is:
  - Couriers routes

*** By changing the input, the model is able to provide the new output with no need to change the model.**

# A3: Specimen Tracking

**Background:**

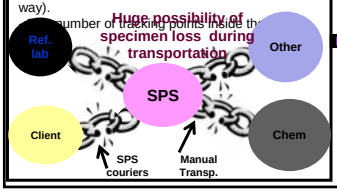
-Specimen loss inside and outside of the lab.
-No knowledge about what is coming until checked in by SPS.




-After being logged in by SPS, every specimen is assigned a barcode.
-Pathology specimens (pass-thru) are not logged in by SPS.
- They can be tracked inside all the lines (Chem., Heme., ..), but specimen loss can still happen before they get to the line.

**Current Condition:**

-No tracking after the drivers pick up the specimens until they are logged in by SPS (on the way).
-The number of tracking points inside the lab is low.

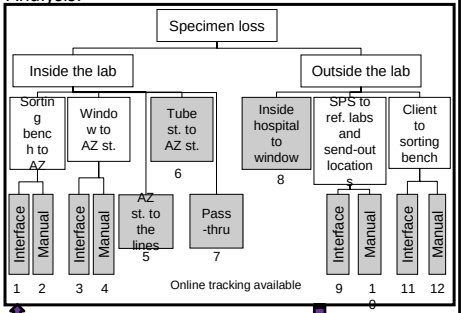



**Goals:**

-Develop a comprehensive tracking system that includes all the clients, SPS, reference labs, and other departments.

-Develop a measurement system in order to accurately measure the specimen loss.

**Analysis:**




**Proposed Countermeasures:**

| Countermeasure | Description | Benefit | Support |
|---|---|---|---|
| Pilot a manual tracking process | Manual logs to be filled out | 2,4,7,10, 12 | Transport ation |
| Increase the tracking points inside the lab | Placing more barcode scanners | All | Chuck |
| Develop a UPS-type ordering & tracking program for all manual clients | Proposal to be written | 2,4,7,10, 12 | IT |

**Plan:**

-Pilot a manual tracking log Oct. 4
-Increase the scanning points inside the lab TBA
-Develop a UPS-type ordering & tracking for manual clients TBA

**Follow-up:**

-The pilot project will begin on October 4.

## Collaboration between the UW Dept of Industrial Engineering and Dept of Lab Medicine

- Dept of Industrial Engineering :
  - Faculty Head: Dr. Joe Heim
  - Post doctoral fellow  Dr. Shabnam Zangeneh,
    - Graduate students
    - Undergraduates
- Dept of Lab Medicine
  - Faculty: (Hoffman, Chandler, Astion)
    - Graduate students: Debbie Su, Garin Fuhrman
    - Staff: Alicia Edwards, Danny Nguyen
    - Residents / Postdocs: Fred Strathman, Erin Grimm

## Industrial and Systems Engineering Graduate Group

- R&D – oriented toward our clinical work
  - Improve our process with off-the-shelf solutions
  - Improve our processes thru more advanced methods
    - Optimization: staff scheduling, courier routing
    - Specimen protection
    - Workflow including furniture design
- Teaching
  - Lean workshops for staff / management/ trainees
  - Contribute at staff meetings
  - Meet with individual staff  / trainees

## Current ISE Projects

- Instituting Lean (5S, VSM, workflow)
- 24 hour on demand (pull) phlebotomy
- Q Dashboard: Expand and Automate
- Transportation – routing, specimen protection
- Scheduling of staff (staff-workflow matching)
- Improving login of all requisition types
- Incident (QA) reporting / Cancel Credit
- Systematic training
- Hospital Call Ctr

## A current perspective

Quality is optimized by applying industrial engineering approaches to quality in combination with confronting patient safety obstacles not commonly discussed.

## Some significant obstacles to patient safety that are not sufficiently confronted

1. Disconnection
2. Incompetence
3. Absent medical directors
4. Fatigue

## Disconnection as a latent error

- Lab staff are isolated from patient outcomes
- ↑ connection = ↑ urgency for QI.
- Example: Error rates ↓ when care providers and anatomic pathologists develop relationships with accountability.


Disconnection from patients and care providers as a latent error in pathology and laboratory medicine: An interview with Dr. Stephen Raab. 2009. *Clinical Laboratory News*. 35(4): 14-15.

## When patients come to lab meetings

**"The experience created a palpable sense of community in the lab. For weeks following these sessions, we got comments from employees saying how good the experience had been. Our employees' focus returned to the patient.  In closing, we would like to share this advice with CLN readers. If you are still skeptical about bringing patients into the lab, trust us. Your skepticism will evaporate the moment you meet your first patient and hear their story."**

Letter to the Editor: Clin Lab News, April 2010
Cathy Groen, MT (ASCP) and Corinne Fantz, PhD
www.aacc.org/publications/cln/2010/april/Pages/safety2.aspx

## When lab techs visit patient care units

**"Actually seeing a baby undergoing ECMO, while a dedicated care team labored to provide care, affected the technologists deeply. It only took about 20 minutes to create a dramatic shift in their thinking by connecting them to these tiny patients and their care providers. This change has improved teamwork between lab staff and nursing and created a fertile environment for carrying out other quality improvements."**

Letter to the Editor: Clin Lab News, October 2009
Kim Skala, MT (ASCP)
www.aacc.org/publications/cln/2009/october/Pages/1009_safety4.aspx

## 6 ways to overcome disconnection

1. Feedback patient outcomes to lab staff
2. Patients attend lab meetings.
3. Have lab staff attend patient rounds
4. Participate in apologies to patients.
5. Work more directly with nursing. Hear and share their stories.
6. Speak in stark, plain language about patient safety.

Disconnection from patients and care providers as a latent error in pathology and laboratory medicine:  An interview with Dr. Stephen Raab. 2009. *Clinical Laboratory News*. 35(4): 14-15.

## Incompetence

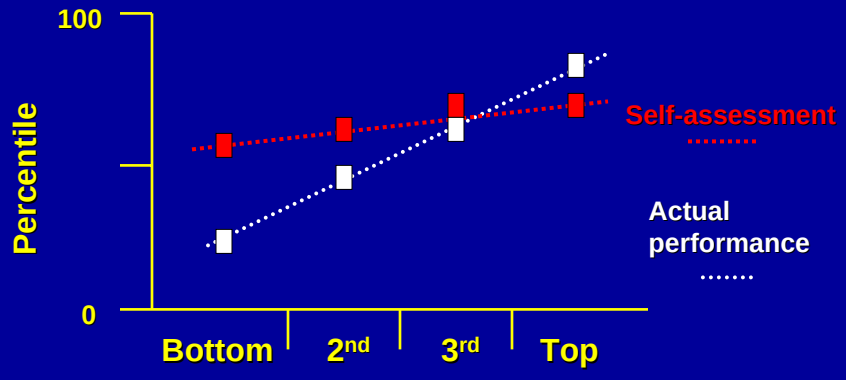
| Rate of mislabeling errors | |
|---|---|
| Nurse-Average | 0.2% |
| Nurse - Joe | 3.0% |
| Next lowest performing nurse | 0.6% |

What would you do with Joe if you could not replace him with a robot?

## Incompetence

- Mismatch of skills with job duties
  - Error rates >> than peers
  - No obvious impairment or recklessness
- Backbone is required to confront mismatch.
  - Chronic mismatch = move to better fit or terminate
  - Temporary mismatch (e.g., (bereavement ) = temporary leave from patient care duties


## The inaccuracy of self-assessment: Use objective competency assessment, not self-assessment




Kruger J, Dunning D. Unskilled and unaware of it…*J Personality and Social Psychology*. 1999;77:1121-1134.

Haun DE, et al. Assessing the competence of specimen-processing personnel. *Laboratory Medicine*. 2000;31:633-637.

## If you are servicing small hospital labs, they may not have an active medical director.

- A lab with an absent medical director is like a ship without a captain
- Hospital pathologists often have $ and cultural incentives to NOT direct the lab

The role of medical laboratory directors in patient safety: An interview with Dr. James Hernandez. 2009. *Clinical Laboratory News*. 35(4): 16-17.

## Fatigue and Errors

- Noncognitive errors: Most errors (e.g. data entry errors, mislabeling errors) are due to lapses in concentration
  - Distractions
  - Interruptions
  - Fatigue
- Cognitive errors: A smaller % of errors are due to to lack of knowledge
  - Monitor it

Mihcael Astion

Michael Astion

| Lab work prone to fatigue errors | Example(s) |
|---|---|
| Rare signal needs detecting | • Detecting rare error flag<br>• Can't find low-abundance organism |
| Multitasking / prioritization | • Tech operating multiple instruments on the same shift<br>• Operating instruments + phones |
| Time gap between when info appears and when it is used | • Critical value calls requiring MD call back. |
| Creative work | • Troubleshooting uncommon errors<br>• Manually validating an infrequent result |

Fatigue and error: An interview with Dr. Matthew B. Weinger. 2009. *Clinical Laboratory News*. 35(1):10-11.

## Load Shedding: Multitasking individuals…

- Often choose high priority tasks, neglect low priority tasks.
- Or, get lost in low priority task, never return to patient care task
  - Supervisor planning parties, not supervising

Fatigue and error: An interview with Dr. Matthew B. Weinger. 2009. *Clinical Laboratory News*. 35(1):10-11.

## Temporary ways to reduce fatigue

- Stimulants (coffee)
- Conversation
- Brighter lights
- Physical activity
- Avoid heavy meals

- Napping, but it has significant tradeoffs.

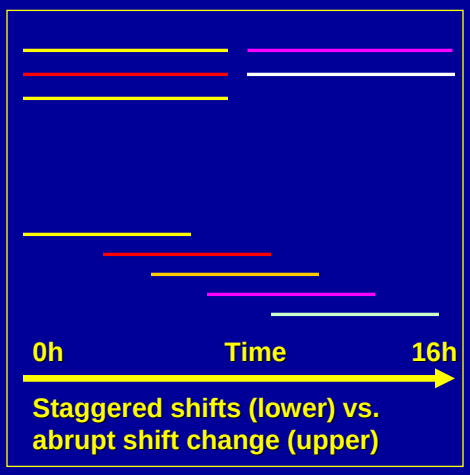
Fatigue and error: An interview with Dr. Matthew B. Weinger. 2009. *Clinical Laboratory News*. 35(1):10-11.

## More permanent ways to reduce fatigue

- Staggered shifts
  - ↓ fatigue
  - ↓ handoffs
  - Freshest workers handle hardest work

- Permanent night shift workers

- Avoid double shifts when short staffed.




Staggered shifts (lower) vs. abrupt shift change (upper)

Fatigue and error:…Dr. Matthew Weinger. *Clin Lab News*. 2009: 35(1):10-11.

## More ways to reduce fatigue and noncognitive errors…

- Remove phones
- ↓ distractions
- Simplify procedures
- Checklists
- Workflow-labor matching
- Automation

- ❑ Milk
- ❑ Coffee
- ❑ Tylenol
- ❑ AA batteries
- ❑ Red wine
- ❑ Pepto

A method to improve memory (and 6 of the most important purchases in my life)

## Conclusion: A Current Perspective

Quality is optimized by applying industrial engineering approaches to quality in combination with confronting patient safety obstacles (like disconnection of lab workers from patient suffering) that are not commonly addressed.