

Automating the Pediatric Laboratory: from Preanalytics to Digital Efficiency

Khushbu Patel, PhD DABCC

March 4, 2025



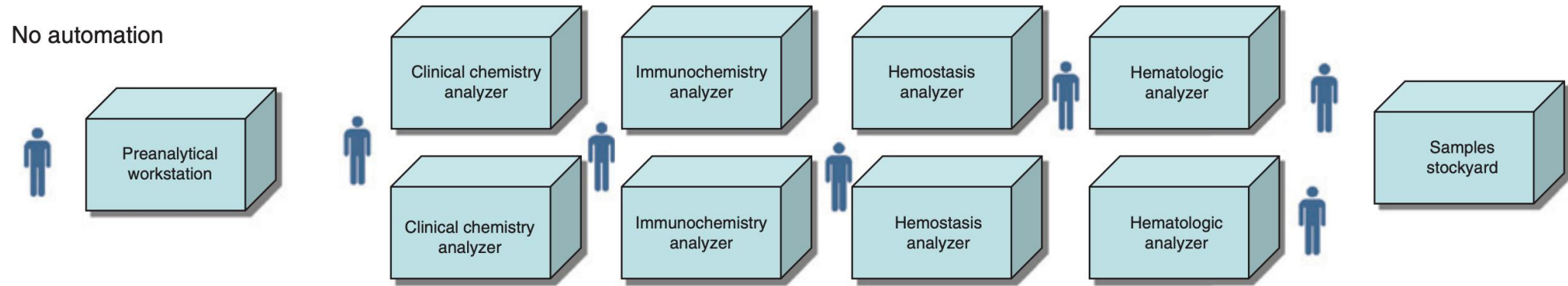
Learning Objectives

At the end of this presentation, participants should be able to:

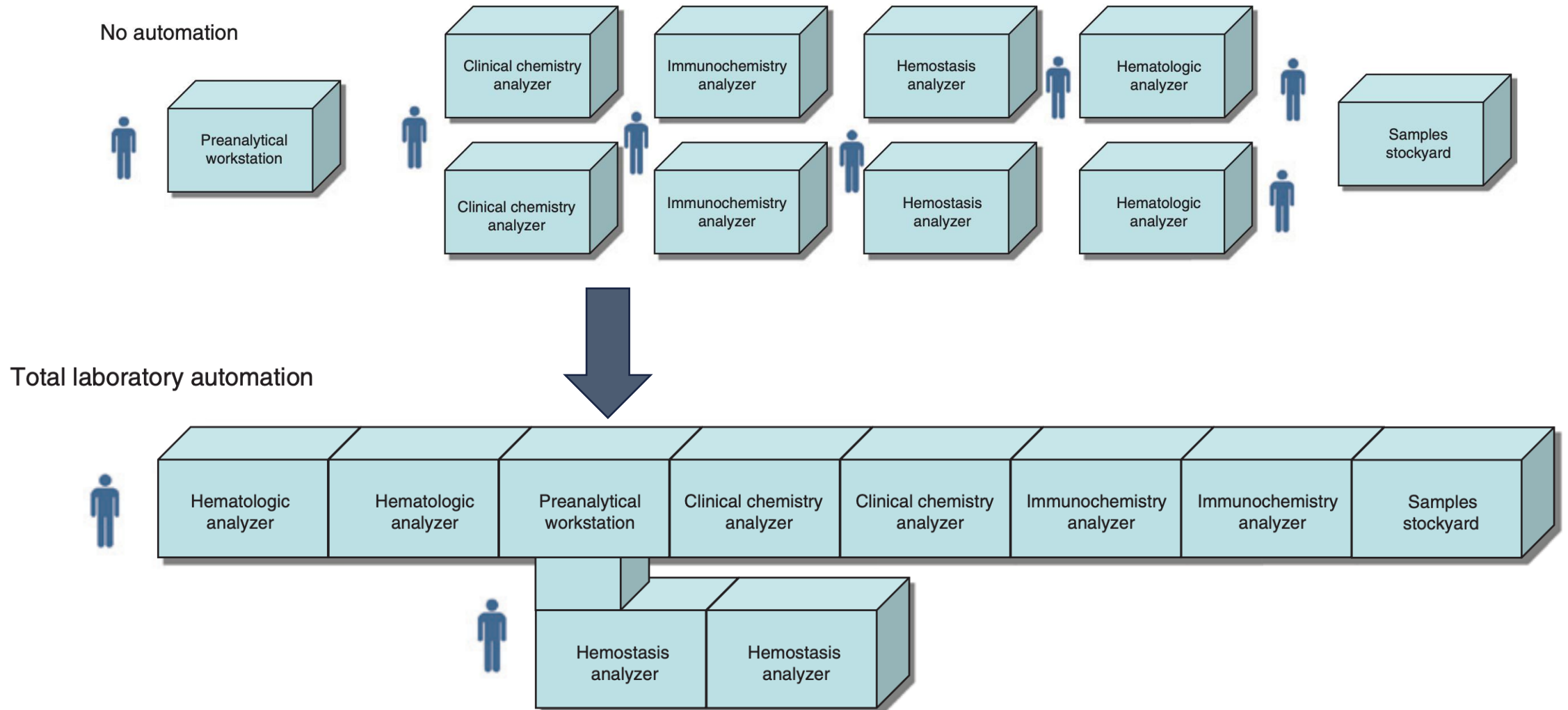
- #1 List at least three benefits and limitations of total laboratory automation (TLA)
- #2 Explain how labs can maximize benefits of TLA
- #3 Discuss how TLA systems can be improved

There is no conflict of interest

The Promise of Total Lab Automation (TLA)



The Promise of Total Lab Automation (TLA)



How has TLA impacted clinical laboratories?

Outline

- Improved efficiency and effect on workforce
- Improved safety
- Improved quality
- Specimen Processing
- Connectivity

What are the effects of TLA on lab efficiency and staffing?

Clinical Chemistry 48:10
1761–1767 (2002)

Automation and
Analytical Techniques

Automated Transport and Sorting System in a Large Reference Laboratory: Part 2. Implementation of the System and Performance Measures over Three Years

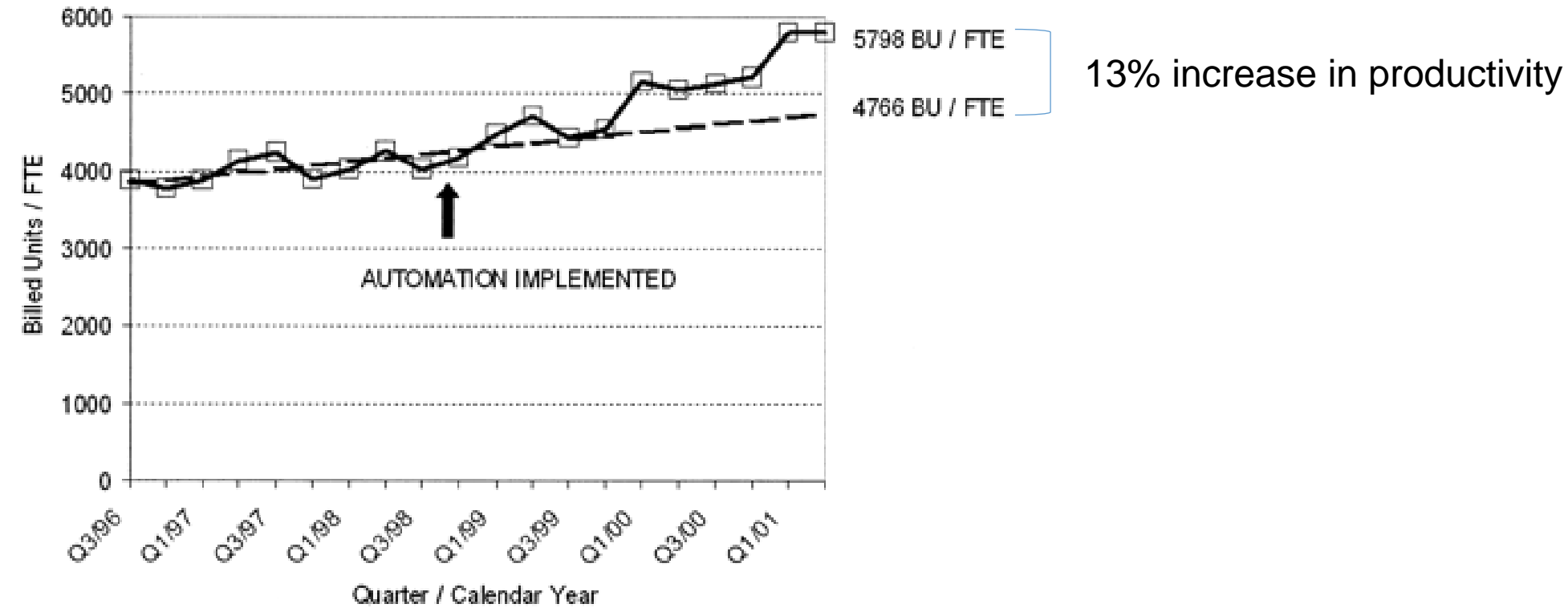
CHARLES D. HAWKER,^{1,2*} WILLIAM L. ROBERTS,^{1,2} SUSAN B. GARR,¹ LESLIE T. HAMILTON,¹
JOHN R. PENROSE,¹ EDWARD R. ASHWOOD,^{1,2} and RONALD L. WEISS^{1,2}

Test menu: 80% of test volume from >1000 tests

Daily volume: >18,000 samples

Clin Chem, Volume 48, Issue 10, 1 October 2002, Pages 1761–1767,
<https://doi.org/10.1093/clinchem/48.10.1761>

Productivity improvements



FTE Savings

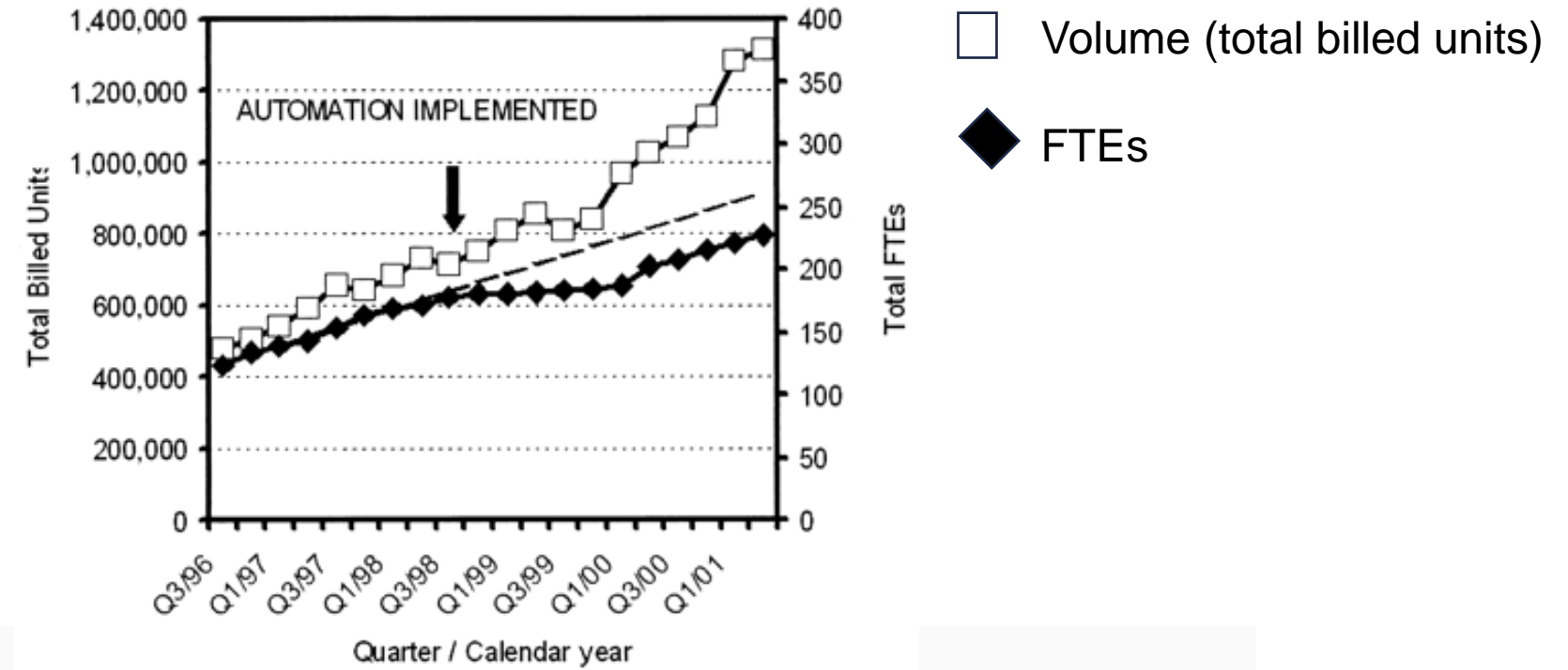


Table 2.
Estimate of ROI.

Savings source	0.625 years	1.625 years	2.625 years	3.625 years ¹	4.625 years ¹	5.625 years ¹
Estimated laboratory FTEs saved (period end)	14.30	21.9	49.1	69.3	96.3	130.8
Average laboratory FTEs saved for period	7.15	18.1	35.5	59.2	82.8	113.6
Labor savings attributable to standardized tube	3.00	3.6	4.2	4.9	5.8	7.0
Total FTEs saved	10.15	21.7	39.7	64.1	88.6	120.6

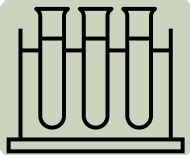
What are the effects of TLA on lab efficiency and staffing?



Decrease in staff needed...till a certain point.



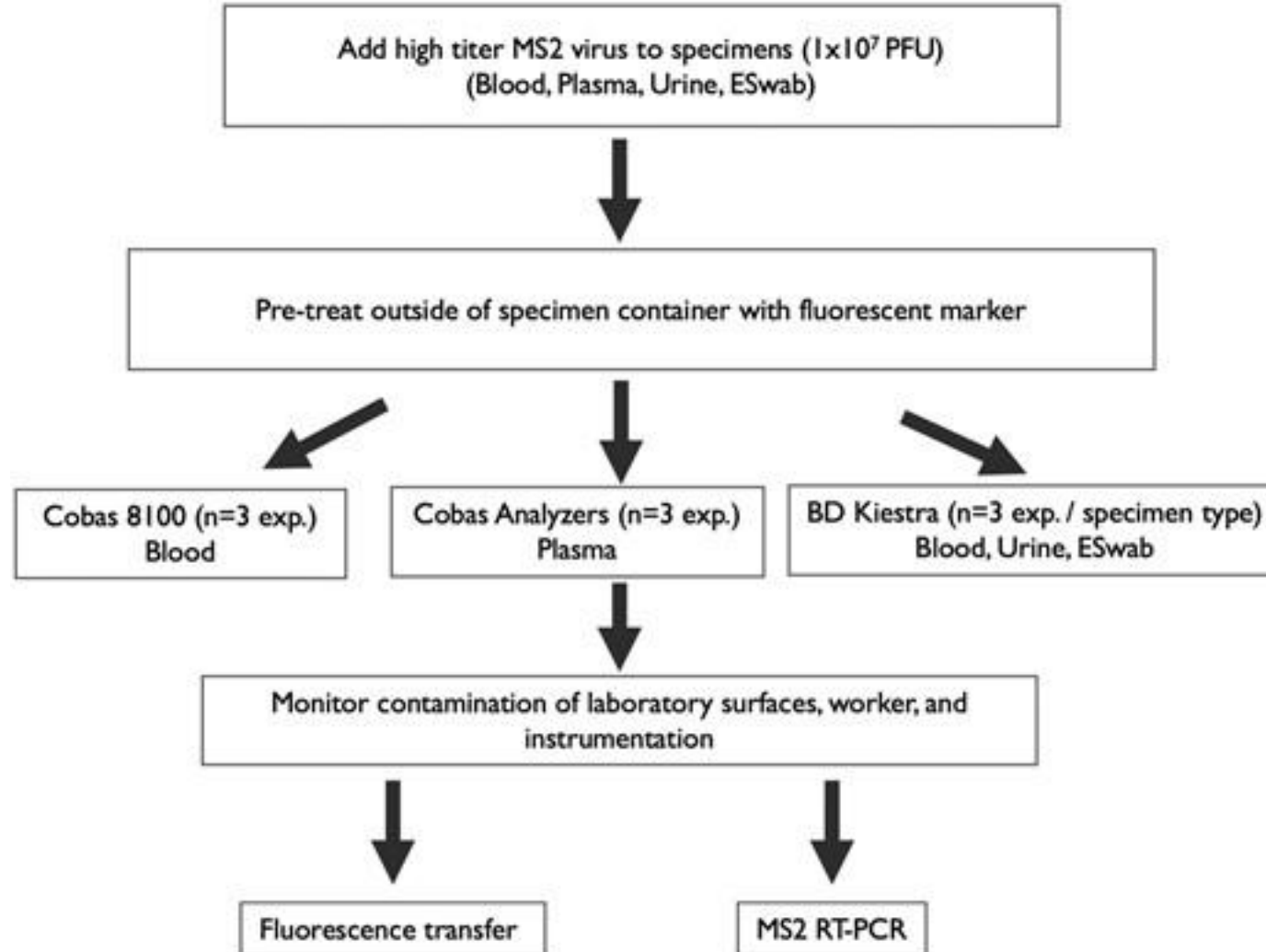
Helps laboratories keep with up with growth.



Selecting the right tests/ areas for automation is essential.

Improved Safety with TLA

Evaluation of contamination on TLA systems



Evaluation of contamination on TLA systems

Table 1

Fluorescence transfer to laboratory workers and environment.

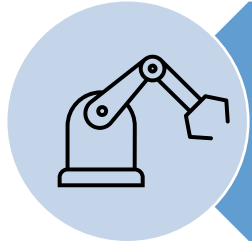
Instrumentation/area	Surface	Chemistry (n=3)	Microbiology (n=6 ^c)	Total, n (%)
Laboratory worker/ receiver				
	Gloved hand (left) ^a	4/4	12/16	16/20 (80)
	Gloved hand (right) ^a	4/4	11/16	15/20 (75)
	Lab coat cuff (left) ^a	0/4	1/16	1/20 (5)
	Lab coat cuff (right) ^a	0/4	1/16	1/20 (5)
	Bare hands	0/3	0/16	0/19 (0)
	Wrists	0/3	0/16	0/19 (0)
	Face ^a	0/4	0/16	0/20 (0)
	Total			33/138 (24)
Receiving area				
	Mouse/mousepad	2/3	5/6	7/9 (78)
	Keyboard	1/3	1/6	2/9 (22)
	Specimen holding rack ^b	1/2	5/6	6/8 (75)
	Desk Phone	–	1/1	1/1 (100)
	Total			16/27 (59)
Total events observed				49/165 (30)

Table 3

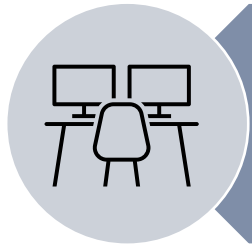
MS2 contamination of laboratory automation and workers.

Instrumentation	Area swabbed	Blood	Urine	ESwab	Total
Cobas 8100	Decapper	0/3	-	-	0/3
	Decapper waste	0/3	-	-	0/3
	Aliquot module arm	0/3	-	-	0/3
	Aliquot drip tray	0/3	-	-	0/3
Chemistry Analyzers	Loading rack	0/3	-	-	0/3
	ISE sample probe	0/3	-	-	0/3
	702 sample probe 1	0/3	-	-	0/3
	702 sample probe 2	0/3	-	-	0/3
	602 pipette/splatter guard	0/3	-	-	0/3
	502 sample probe	0/3	-	-	0/3
	Negative carryover 1	0/3	-	-	0/3
	Negative carryover 2	0/3	-	-	0/3
	Negative carryover 3	0/3	-	-	0/3
	Negative carryover 4	0/3	-	-	0/3
Kiestra	Technician: gloved hands	0/3	0/3	0/3	0/9
	Technician: bare hands	0/3	0/3	0/3	0/9
	Sample rack	0/3	0/3	0/3	0/9
	InoquIA decapper	0/3	0/3	0/3	0/9
	InoquIA vortex area	0/3	0/3	0/3	0/9
	InoquIA pipette	0/3	0/3	0/3	0/9
	InoquIA drip tray	0/3	0/3	0/3	0/9
	Area around tip waste	0/3	0/3	0/3	0/9
	Bead waste area	0/3	0/3	0/3	0/9
Total		0/69	0/27	0/27	0/123

What can be done to improve lab safety with TLA?



Processing of contaminated specimens on automation presents low likelihood of instrument contamination



Contaminated specimen containers can lead to lab environment contamination

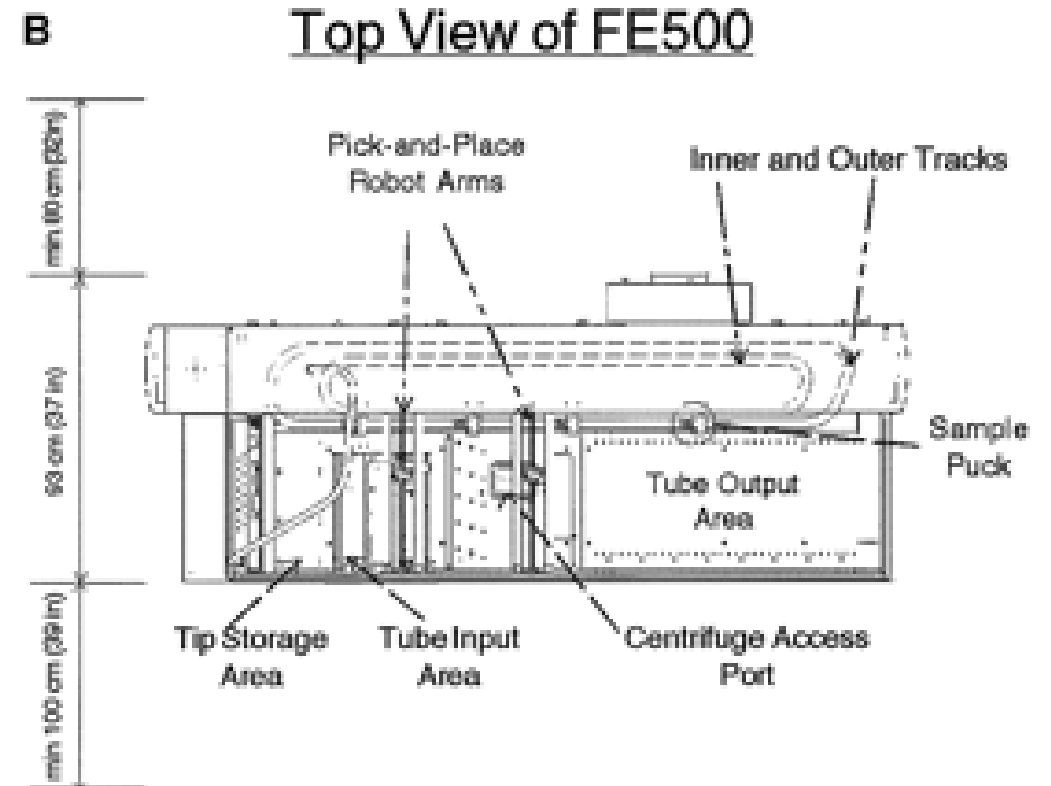
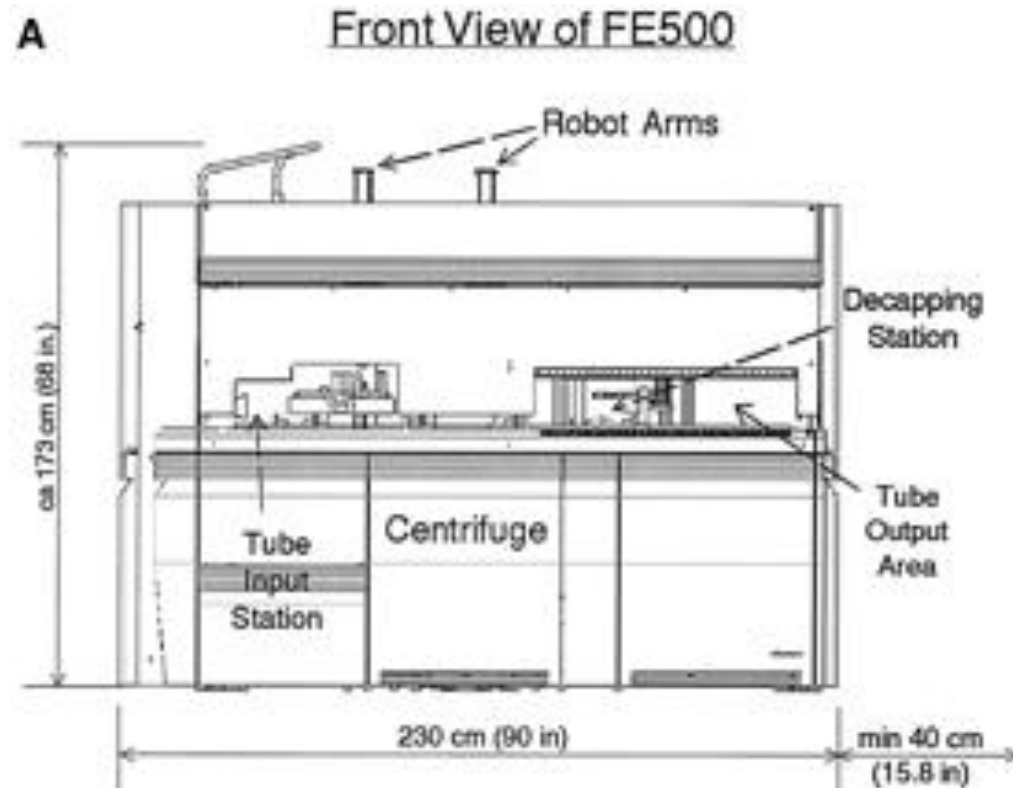


Lab specific risk assessment should be performed. TLA is not a substitute for adherence to universal precautions



Improved Quality with TLA

Error Reduction



Error Reduction

Table 2. Effects of FE500 on specimen-processing errors.^a

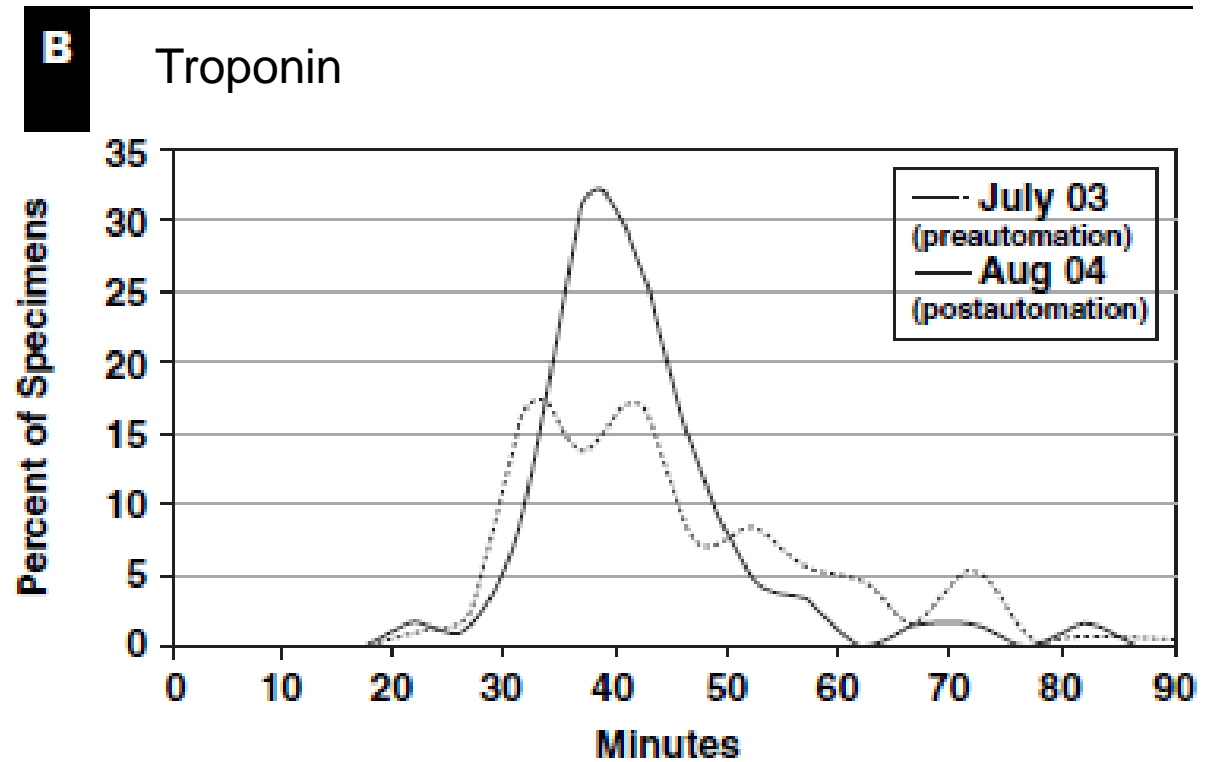
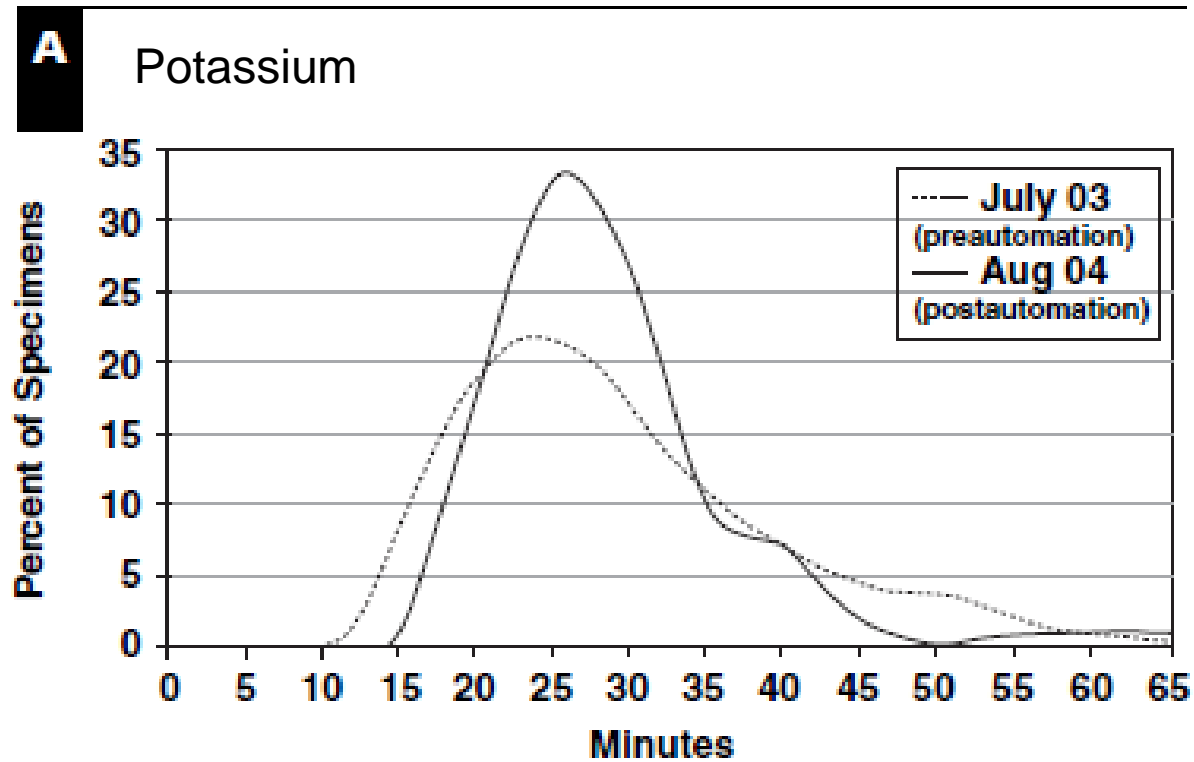
Error/event classification	No. of errors/events per month	
	Pre-FE500 ^b	Post-FE500 ^c
Sorting and routing errors	7950	477
Pour-off errors	2612	96
Labeling errors	6668	33

^a Study performed at Milton S. Hershey Medical Center, Pennsylvania State University (Hershey, PA).

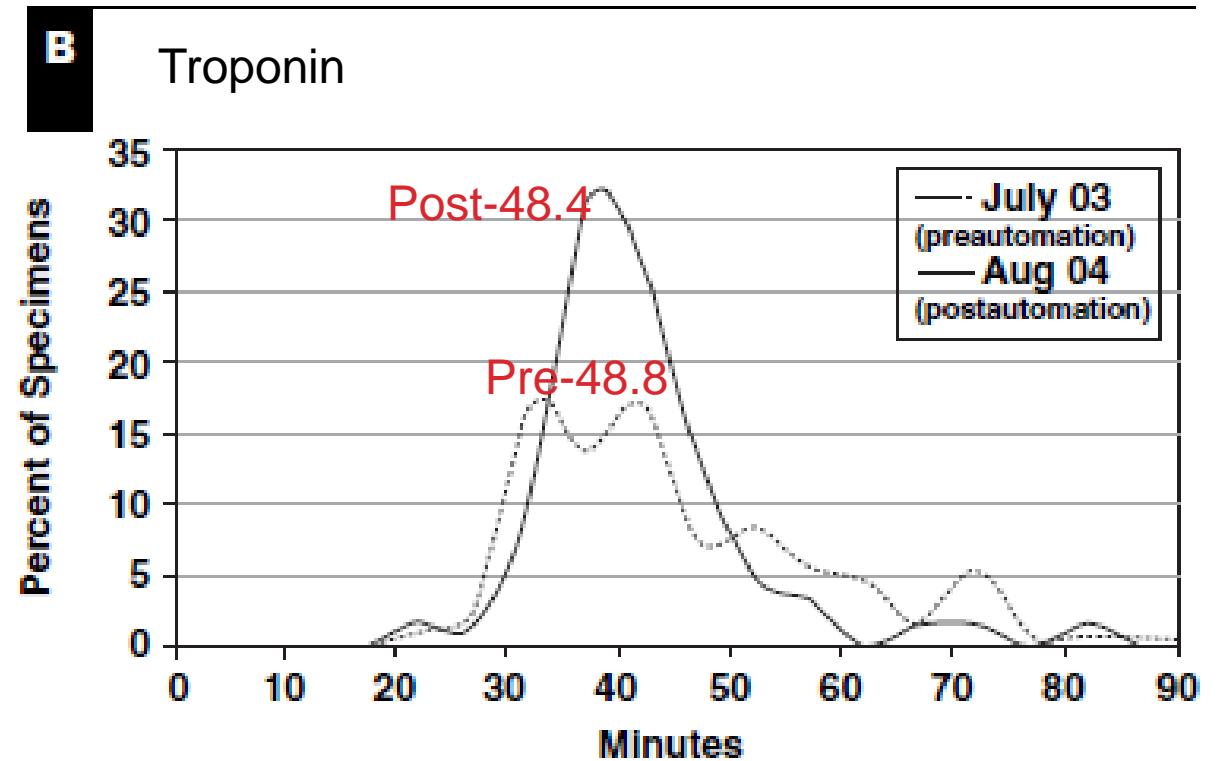
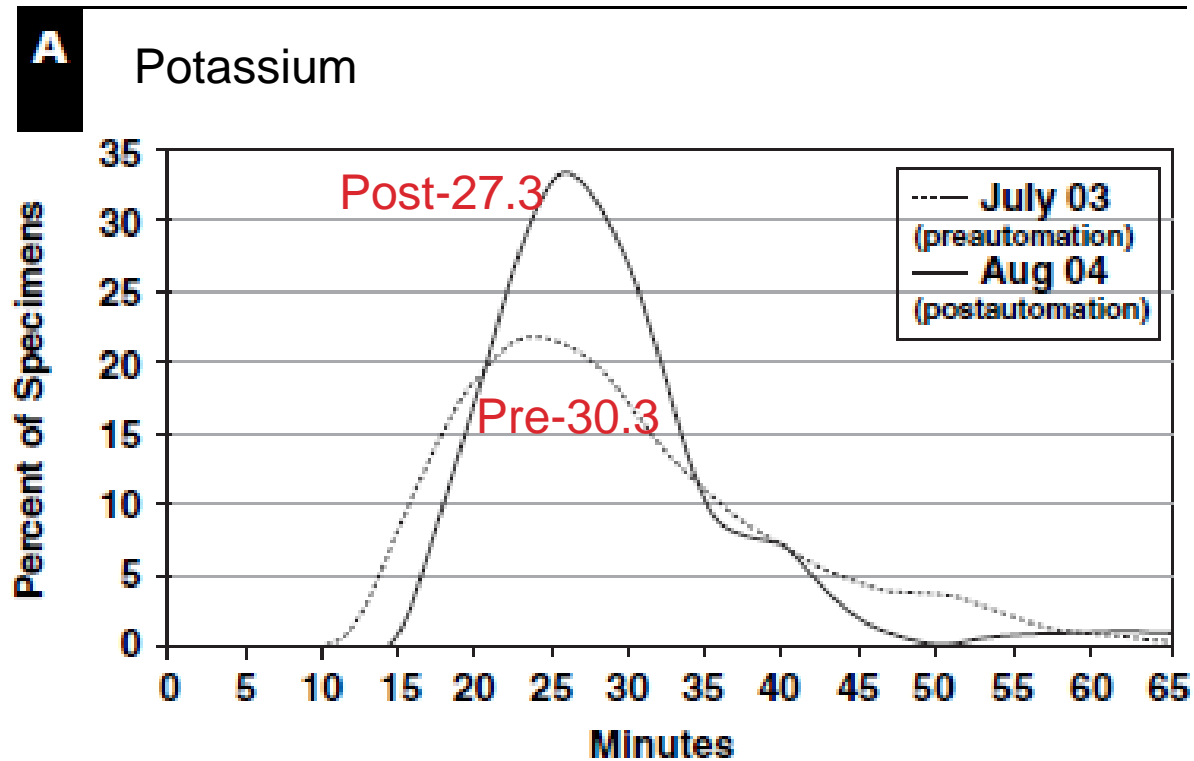
^b Estimated for 1-month period of data collection.

^c Errors recorded in this category were largely identified from specimens processed for stat testing. Stat specimens are currently not processed by the FE500 in our laboratory.

TLA Effect on Mean TATs



TLA Effect on Mean TATs



TAT means did not change significantly
TAT outlier percentage did decrease significantly

Challenges in Specimen Processing

Container Types

- Automation systems require standardized collection containers.



Container Types

- Specimen containers come in all shapes and sizes (esp. urines and micro)



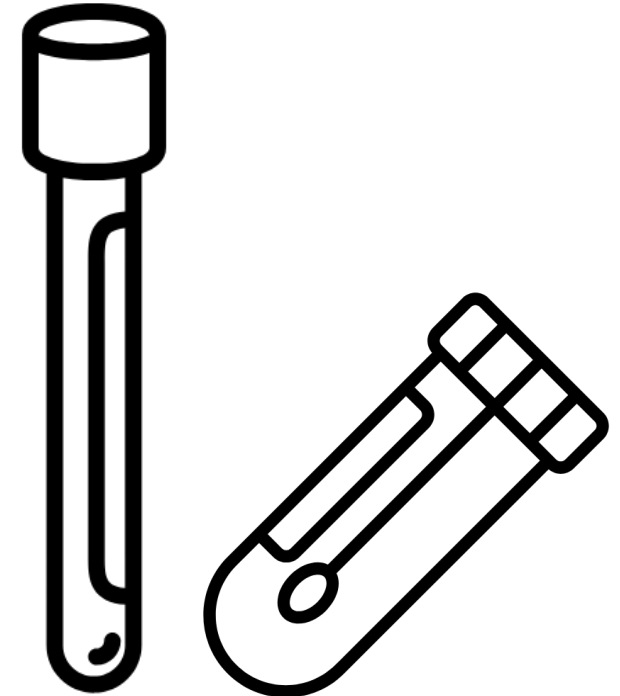
Why has automation in pediatrics lagged?

- Lack of standardization of collection devices
- Complexities of specimen processing
- **Limited sample volume**



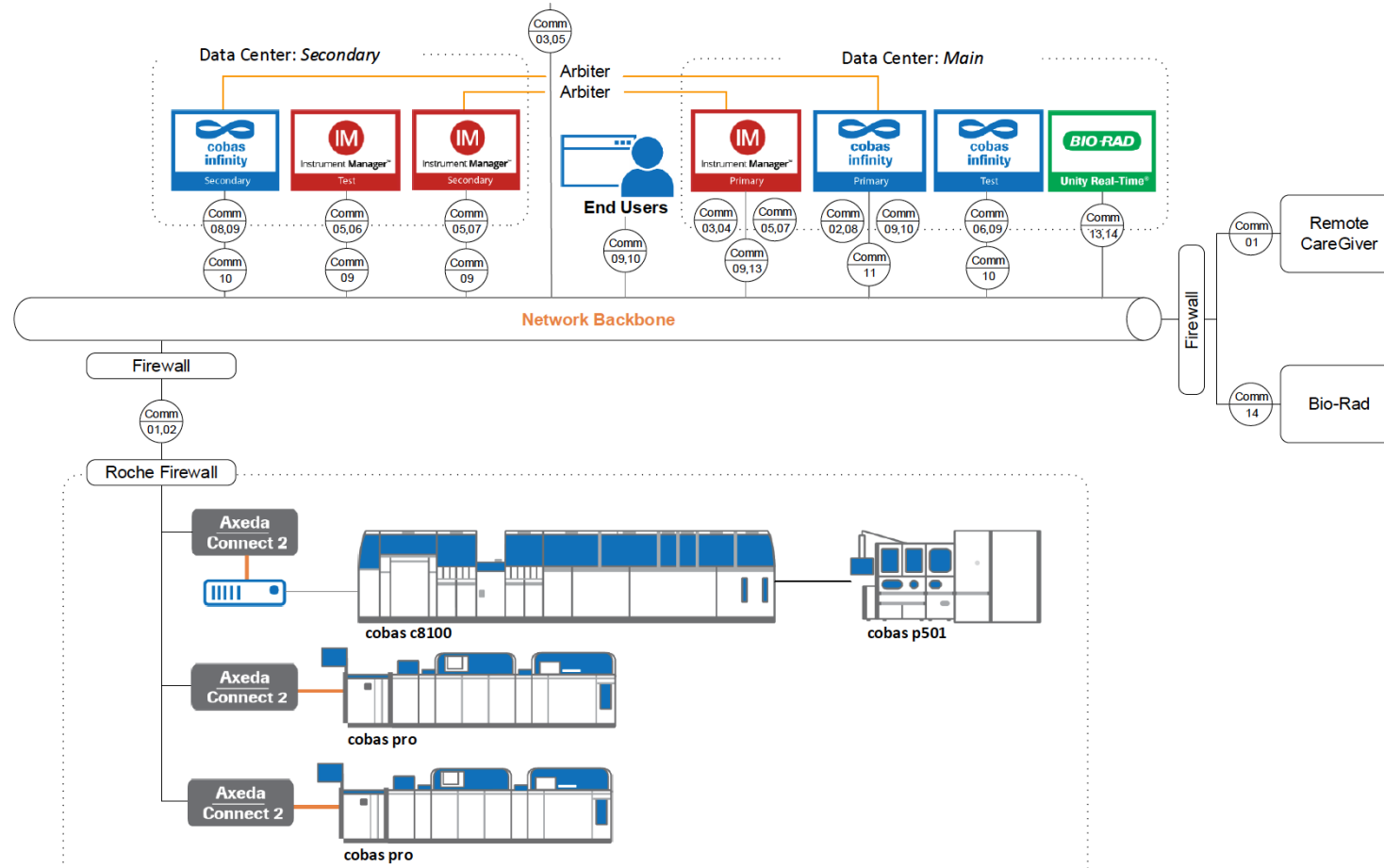
What can you do to improve sample processing with automation?

- **Plan ahead!**
- Make sure the automation system meets the need of your patient population
- Standardize containers
- Validate labels
- Train staff to look for improper labeling
- Educate nursing and phlebotomy staff



Connectivity

Complex Data Infrastructure



LIS vs. middleware

- Autoverification
- QC checks
- Reference ranges
- Result comments
- Calculations

Equipment not included in “Total”

Core Laboratory

- Most are single vendor systems
- Urinalysis
- Blood gas
- Stat lateral flow/ POC tests
(qual pregnancy,
infectious disease)
- Mass spectrometry

Manufacturer-Driven Laboratory

- Once “total Lab” automation selected, hard to select other instrument manufacturers

Manufacturer-Driven Laboratory

- “We recommend that companies agree on common shapes and sizes of racks and include more flexible robotic technology in their sample handling systems, to allow for plug and play systems and to make systematization affordable for every laboratory in the world.” – M. Sasaki



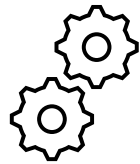
Fig. 1. Laboratory technicians at Kochi Medical School assembling elevated conveyor belt line. The laboratory workers built the automated laboratory system with their own hands.

Take home points

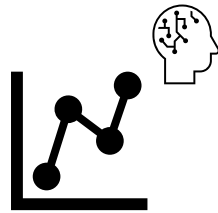
- Benefits:
 - Alleviates staff workload
 - Improves safety through decreased exposures
 - Improves workflow efficiency and reduces errors
- Challenges:
 - Connectivity issues between platforms/ vendors
 - Changes in workflows and staffing
 - Requires significant planning and capital investment
- Implementation:
 - Automate the right areas (high volume, repetitive tasks)
 - Standardize collection containers
 - Don't forget about downtime!
 - Change management- emphasize benefits and prepare

Future Directions: Emerging Applications in TLA

Automation



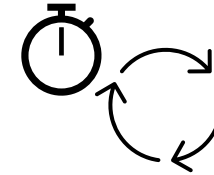
Data analytics/AI



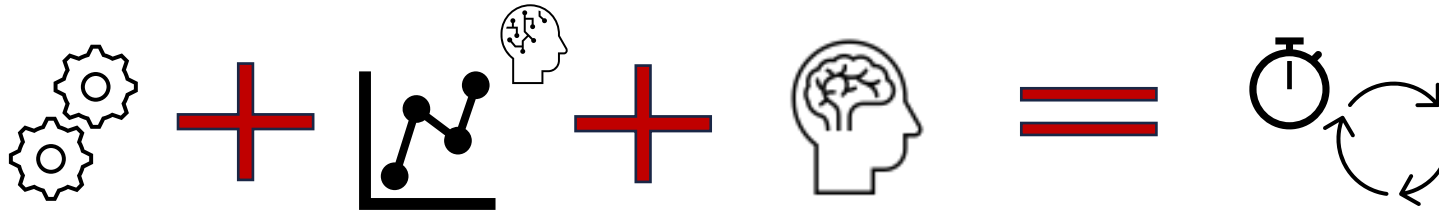
Expertise



Time and efficiency



Future Directions: Emerging Applications in TLA



- QC failure prediction
- Detecting faulty reagents or equipment

- Delta checks, integration of EMR data for flagging interferences
- Detecting preanalytical errors (IV contamination, wrong tube)

- Integrated critical result communication
- Inventory management
- Automated reagent and supply ordering
- Automating Manual dilutions and QC troubleshooting

Thank you!
patelk35@chop.edu



Digital Automation: Implementation of an Electronic Closed-Loop Communication System for Critical Lab Results

Tracey Polsky, MD, PhD

March 4, 2025



Learning Objectives

- Understand the barriers to implementing automation in the pediatric clinical laboratory.
- Provide examples of how to design automated systems (instrumentation and electronic workflows) that meet the needs of pediatric patients.
- Discuss how the Laboratory Information System and Electronic Medical Record can be optimized to help automate lab orders and results.

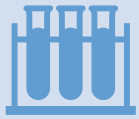
Background

What is a Critical Lab Result?

- Critical results are laboratory results that are considered life threatening and require immediate notification to the appropriate responsible health care provider.



High Volume of Critical Lab Results



The CHOP Clinical Laboratory results approximately 40,000 critical lab values per year.

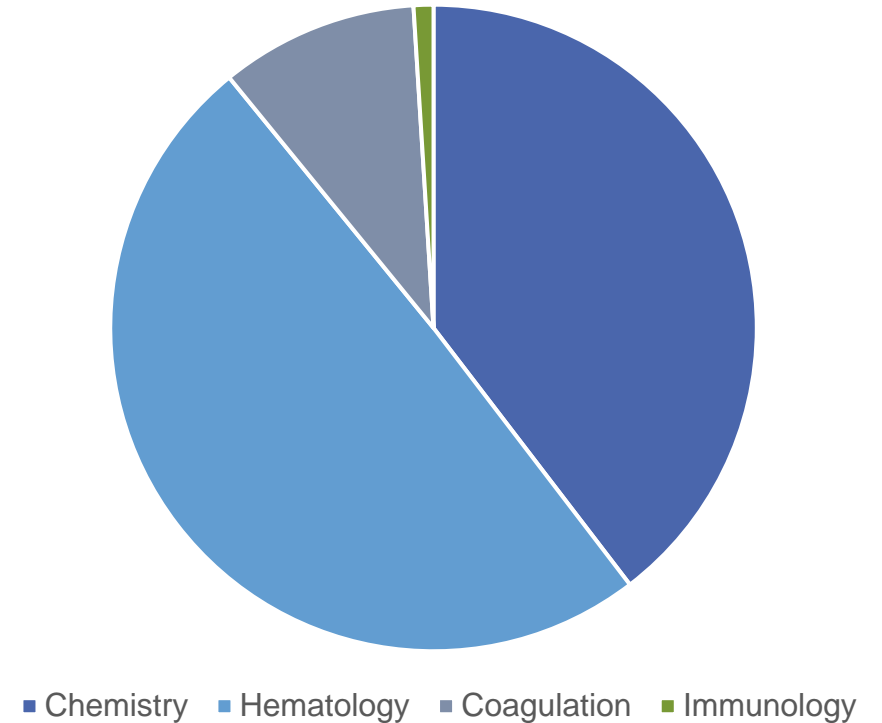


75% of these were to nursing per CHOP Policy.

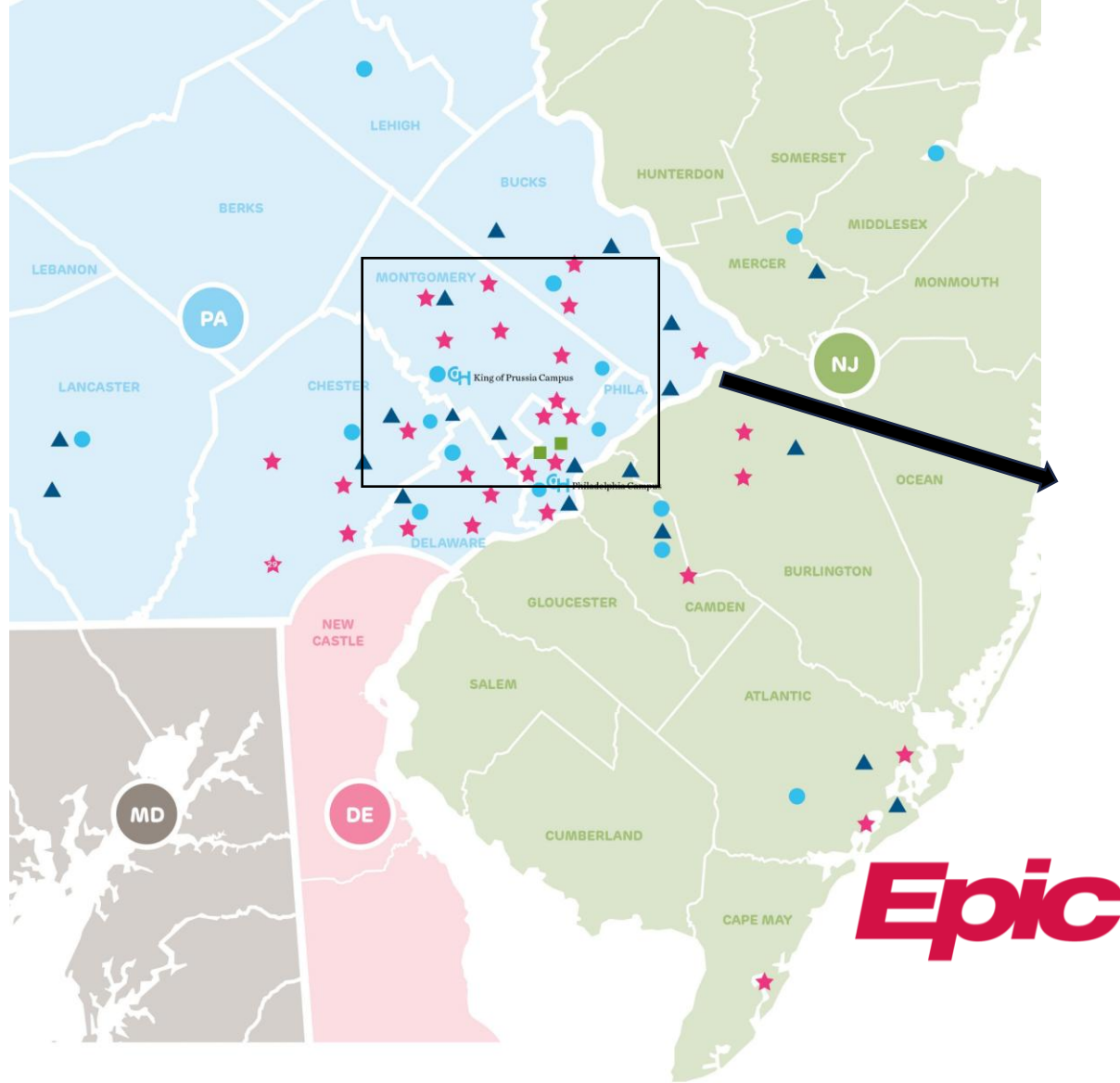


Prior to December 10, 2024 – CHOP Laboratories were using phone calls to report critical lab results.

Critical Value Percentages By Lab



CHOP Enterprise



LEGEND

-  Inpatient Hospitals
-  Primary Care Practices
-  Specialty Care Centers
-  Behavioral Health Centers
-  Hospital Affiliates



©2024 The Children's Hospital of Philadelphia.
24NET23A36J/PDF/08-24



Critical Value Reporting Workflow

Lab verifies a critical result

Lab decides whether results requires a phone call

Lab locates provider who should be notified per policy

Lab calls Attending Provider or Bedside Nurse to verbally report value

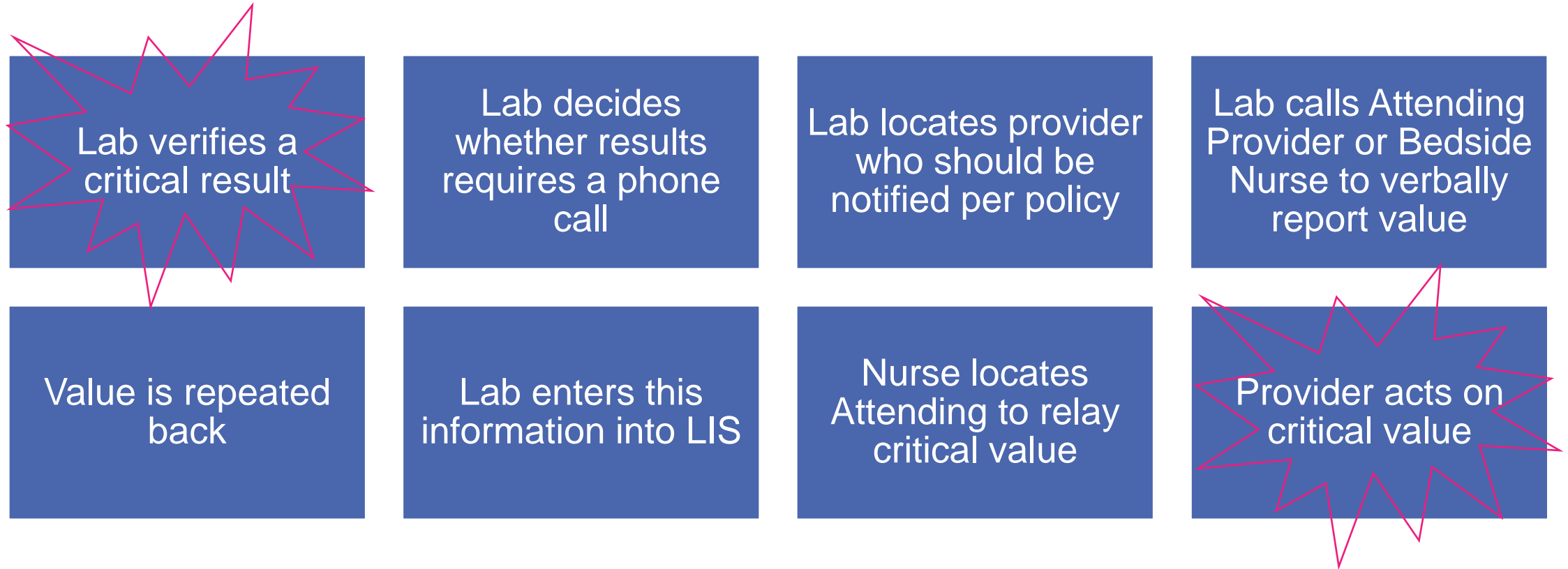
Value is repeated back

Lab enters this information into LIS

Nurse locates Attending to relay critical value

Provider acts on critical value

Critical Value Reporting Workflow



Phone Calls are Inefficient



Lab staff spent an average of 7 min/call = 4600 hours and \$200,000 annually.



Nurses spent an average of 5 min/call = 2500 hours and \$120,000 annually.



Calls are delayed relative to lab result verification and may have already been seen by Provider.

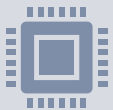
Critical Value Reporting Assessment



Problem: Reporting critical lab values via phone call is time consuming for lab staff and providers and disruptive to patient care.



Provider Feedback: Prefer electronic communication; however, secure chat not preferred modality. Opportunity to standardize procedures across enterprise and remove nursing from critical value workflow.

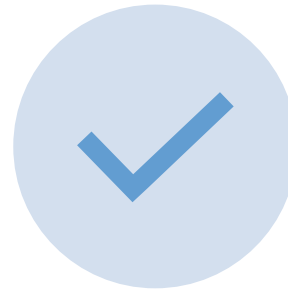


Solution: Implementation of Epic's closed loop electronic communication system for critical lab results.

Overview of Closed-Loop Critical Result Communication Workflow



Physicians receive push notifications for new critical results



These can be electronically reviewed and acknowledged

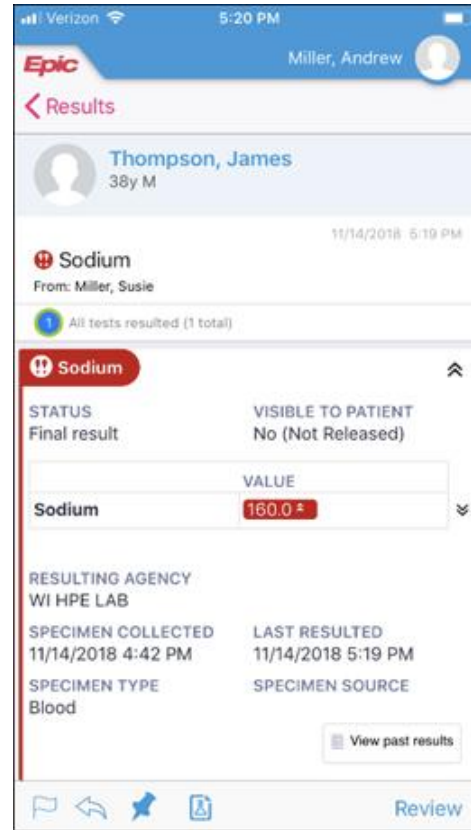
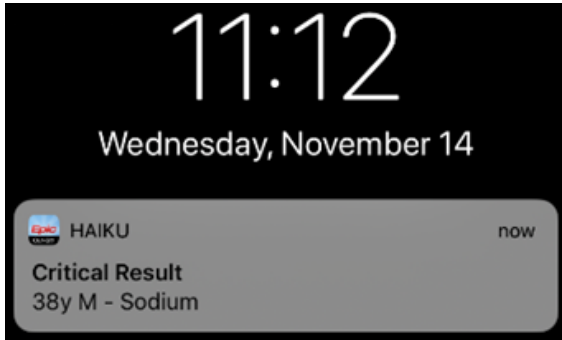


Lab staff can see when results have been reviewed and acknowledged by the provider



No phone calls need to be made (unless follow up needed)

Example Closed-Loop Workflow



Follow-up Work List - Critical Call Review - 1 of 5 selected

Critical Call Timer	Patient/MRN	ID	Test	Authorizing Provider
43m	Murray, Samantha (207647)	S: 18H-318C0019	CMP	Bill Alpers
36m	Johnson, David (204150)	S: 18H-318G0002	aPTT	Emma Hauser
34m	Harris, Julie (207648)	S: 18H-318M0004	Clostridium difficile...	John Lebert, MD
22m	Brown, Alexandra (202398)	S: 18H-318C0021	Basic Metabolic Panel	Barney Smith, MD
8m	Blake, Matt (207649)	S: 18H-318G0003	Protime-INR	Joseph Allen

Lab monitors a real-time call list.



Specimen: 18HE318CH037 Sodium

User: Status: Completed

Critical Results

Started	Completed By Miller, Andrew	Completed 11/14/2018 5:20 PM
---------	--------------------------------	---------------------------------

Acknowledged by

User Miller, Andrew	Time Read / Acknowledged 11/14/2018 05:20 PM
------------------------	---

History

Event	Occurred
Completed	11/14/2018 05:20 PM by Miller, Andrew
Comment: Result Acknowledged	
Task Created	11/14/2018 05:19 PM by Lab, Admin

In Haiku, physician reviews new results. Physician acknowledges.

Task will automatically close after review and show documentation in Epic.

*Two ways to set up push notifications:

- 1: Send critical results to users who already receive an In Basket message for that result.
- 2: Send notification to treatment team role(s) that you specify (no In Basket)

Benefits of a Closed-Loop Workflow



Push notifications allow real time communication of critical results – better integration into clinical care.



Read back step eliminated – saves time and reduces room for error.



Fewer interruptions for lab staff to make and receive calls – sometimes multiple calls.

Key Questions: Potential Barriers to Implementation



Does your institution use Epic as the EMR and LIS?



Does your institution have resources to dedicate to the system build?



Do providers already use Haiku and Canto with push notifications?



Does your organization use Treatment Team roles?



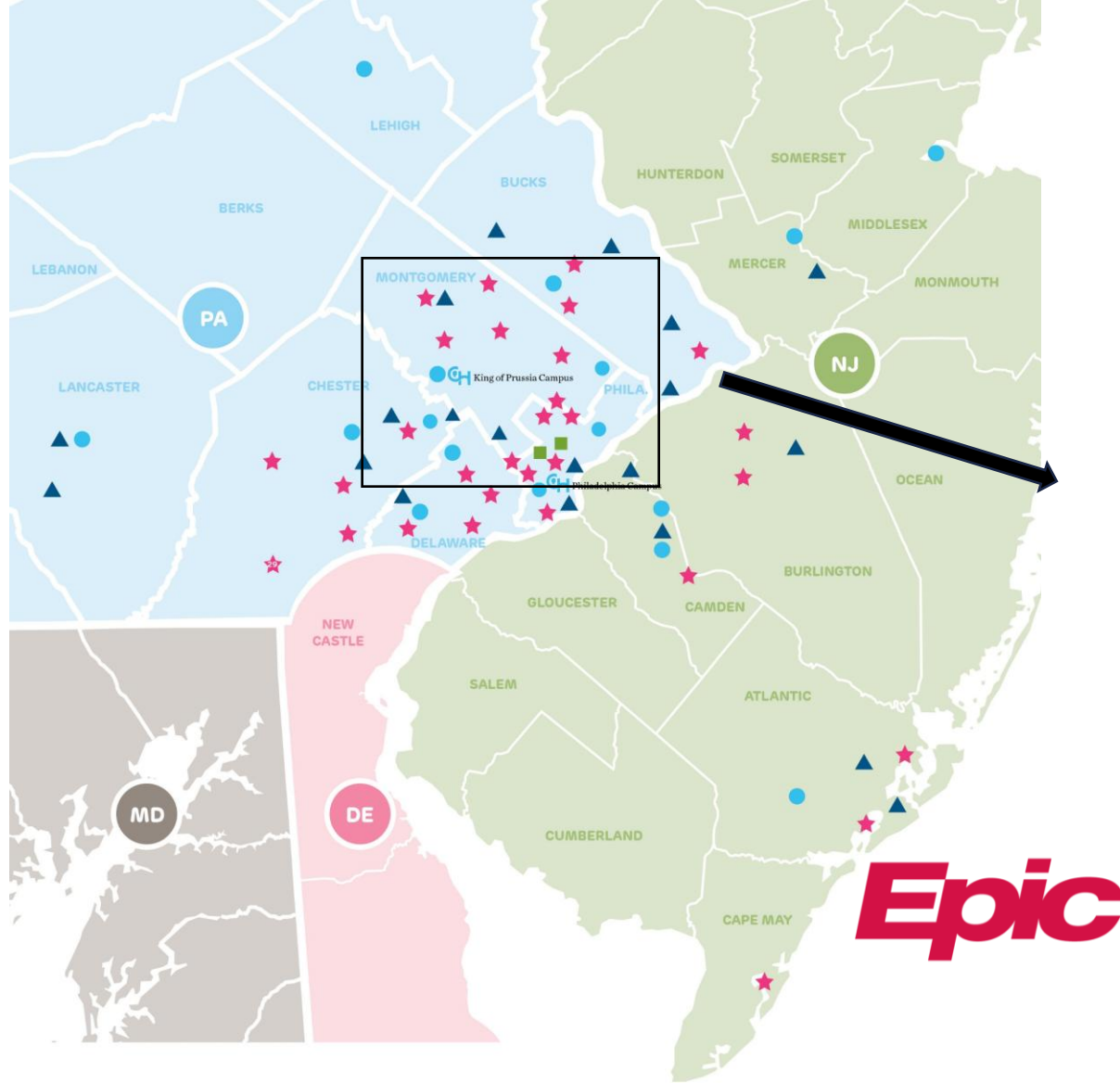
Who should receive/view/acknowledge push notifications?



How should the Lab handle outstanding notifications?

Implementation

CHOP Enterprise



LEGEND

- Inpatient Hospitals
- Primary Care Practices
- Specialty Care Centers
- Behavioral Health Centers
- Hospital Affiliates

Children's Hospital of Philadelphia[®]
CARE NETWORK

©2024 The Children's Hospital of Philadelphia.
24NET23A36J/PDF/08-24

Project Scope: All patient care workflows at both CHOP Hospital Campuses, along with outpatient medical specialty, surgical and primary care.

Children's Hospital of Philadelphia[®]

Project Details



Project Scope: All patient care workflows at both CHOP Hospital Campuses, along with outpatient medical specialty, surgical and primary care.



Goal: To achieve at least 75% electronic acknowledgement of critical value notifications within the first two months of implementation.



Process: A workgroup of clinical care providers, including attendings, residents, APPs, and nurses, supported the implementation (collaboration between Digital and Technology Services and Lab Medicine).

CHOP Closed Loop Electronic System Overview

THE CLINICAL LAB VERIFIES A CRITICAL RESULT.



A PUSH NOTIFICATION IS SENT ELECTRONICALLY TO DEFINED PROVIDERS IN BOTH HAIKU AND HYPERSPACE.



PROVIDERS ACKNOWLEDGE THE CRITICAL VALUE FROM THE NOTIFICATION.



THE LAB MONITORS AND ESCALATES TO A PHONE CALL AFTER 10 MINUTES.



THE LOOP IS CLOSED WHEN EITHER A PROVIDER ACKNOWLEDGES ELECTRONICALLY, OR THE LAB CALLS TO REPORT THE VALUE.

Notification Recipients by Clinical Service



Inpatient notifications: Leverage the Treatment Team (Front Line Clinician and Supervising Resident). Highly reliable due to our use of the Unified Communications Suite.



Outpatient notifications: Ordering and Authorizing Providers.



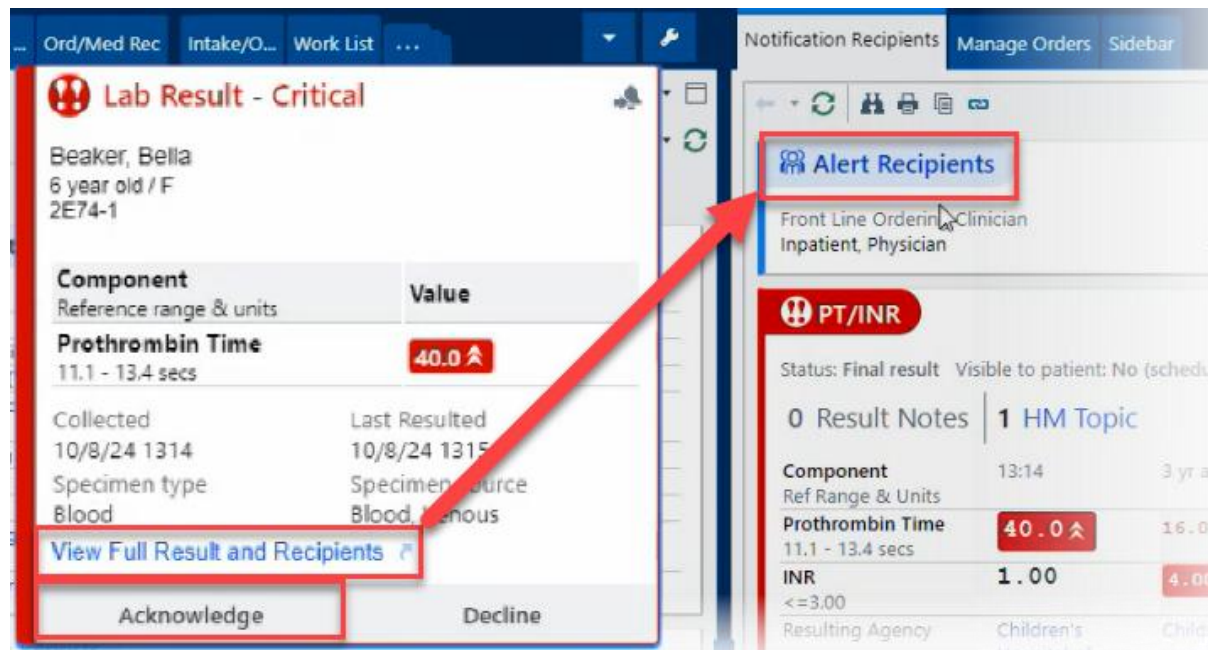
Lab: Escalation (phone call) pathways include the Fellow and Attending on Call.



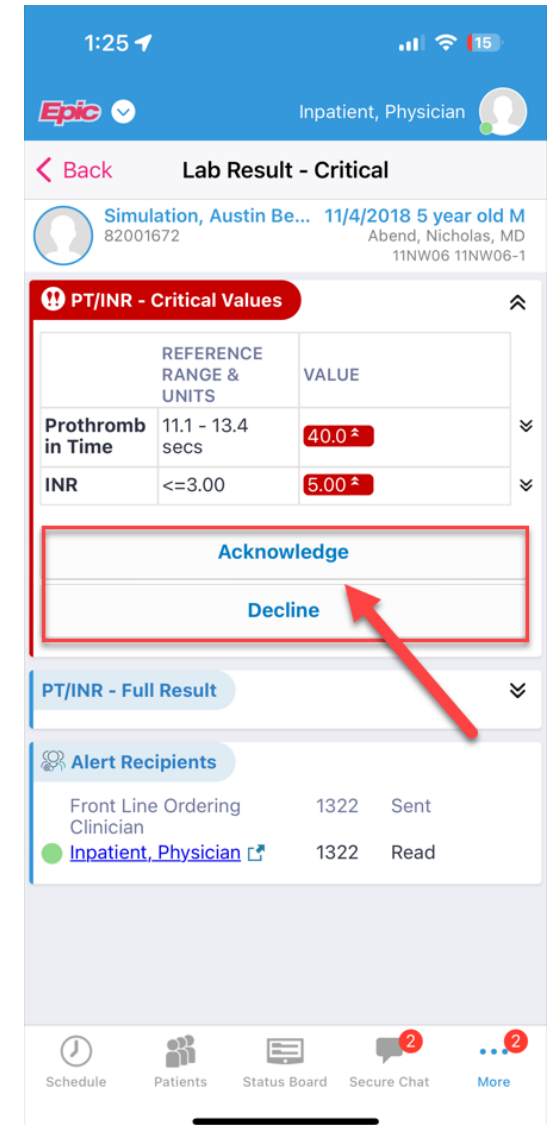
If there is no provider signed in at the time of critical test result, the lab will report via phone call.

Closed Loop Electronic System – Provider View

- Multiple providers are notified – only ONE needs to acknowledge to close the loop.
- Once acknowledged, the notification disappears for all.
- The information for who acknowledged and when will be captured in Epic.



Desktop if logged into Hyperspace



Haiku

Closed Loop Electronic System – Lab View

- Lab staff monitor a worklist of all critical results – the result falls off the list when a provider acknowledges.
- If over 10 min has elapsed, the result will turn red, and the lab will escalate to a phone call and close the loop manually.
- The alert will close for all recipients.

ticals - Push - 1 out of 58

Submission Entry Results Documents Labels

Action	Added	ID	Pati
OAG	10/08/2024 13:32	S: 24U-HC-2820019	Sim
OAG	10/08/2024 11:53	S: 24U-HC-2820009	Sim
OAG	10/08/2024 11:08	S: 24U-HC-2820003	Dev
OAG	10/03/2024 14:52	S: 24U-HC-2770003	Tes
CHEM	10/01/2024 09:45	S: 24U-CH-2750002	Ami
MM	09/30/2024 14:11	S: 24U-IM-2740001	Ami

Pre Go-Live Education

Tip Sheets were assigned electronically to Providers and Lab Staff

Introduction

The way you receive critical laboratory results is changing. Currently, the lab notifies you of a patient's critical results directly by phone. On December 10, 2024, you will receive a push notification on your mobile device and desktop. This applies to all critical laboratory results. Notification procedures for Radiology and Point-of-Care Testing critical results are unaffected.

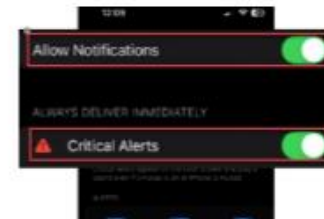
Need to Know:

- Conditions of critical results are not changing; only the process of how they are sent.
- Electronic notifications will be sent to your mobile device AND desktop (while logged in). You will need to acknowledge the result once. Alerts and acknowledgments are synchronized between desktop and mobile platforms using the same acknowledgment and escalation flows.
- If a critical result is sent to more than one provider, only one person needs to acknowledge the result. The alert will pull back for all others who were notified.
- Information for who acknowledged the critical result and when will be captured in Epic.
- Lab will monitor and escalate to a phone call if the notification is not acknowledged after 10 minutes.
- Only an electronic acknowledgment by a provider or a verbal communication by the lab will clear the alert and pull back the notification.
- When the lab closes the Critical Call result loop, missed or declined notifications will no longer be available in Epic.
- When using a desktop, historical notifications will not be available if you log-out of Epic.
- Unchangeable in your mobile workflow, it is imperative that you sign into your patient's care as you do today to receive the critical results.
- Current electronic result routing (e.g., results to Pools) will remain the same.

Current	Future
Phone call.	Receive notifications on your mobile device or desktop. Notifications may be sent to multiple providers who can acknowledge the critical result.

Important

On December 10, 2024, it is important to ensure that notifications on your mobile device to have the correct defaults. *Allow* and *critical alerts* must be turned on for critical result notifications.



Children's Hospital of Philadelphia™
DTS Learning Services

Epic: Medical Laboratory Scientist

Closed Loop Critical Results Communication

Revised:
Reviewed:

Introduction

The process of contacting providers with critical results has been updated. Currently, you notify the provider of a patient's critical results directly by phone. On December 10, 2024, Epic will automatically send a push notification to defined provider roles in Epic via Haiku and on the desktop. You will monitor the updated *Follow-up Work List – Call Criticals* report to ensure a provider acknowledges the critical result.

If the notification is declined by all providers who receive the notification or no one acknowledges the result within 10 minutes of being notified, you will call the provider based on the *Electronic Critical Communication Notification Table - Electronic Critical Comm Notification Table.pdf*. All critical values must be acknowledged electronically or verbally communicated within 60 minutes.

This applies to all critical laboratory results. Notification procedures for Special Coagulation, Delta Hemoglobin, Requisition entry orders, and Courtesy/Alert values remain unaffected.

Getting Started

Add the *Follow-Up Work List: Call Criticals* report to your dashboard.

1. Click **Views**.
2. Click **Settings**.

Metrics and Impact

Regulatory Considerations

- COM.30000 Critical Result Notification: The laboratory has written procedures for immediate notification of physicians or other clinical personnel responsible for patient care when results of designated tests exceed established "critical" values. Records of notification are retained.
 - NOTE: An appropriate notification includes a direct dialog with the responsible individual or an electronic communication (eg, secure email or fax) with confirmation of receipt by the responsible individual.
- COM.30100 Critical Result Read-Back: For verbally communicated critical results, personnel communicating results request and record "read-back" of the results.
 - NOTE: If critical results are transmitted electronically (eg, secure email or fax), the laboratory must confirm receipt by the responsible individual; however, no read-back is necessary.

Efficiencies of a Closed Loop System



Standardized policies and procedures



Notifications direct to attending/ordering providers



Lab staff less interrupted by calls and documentation



Communication occurs in real time with result reporting

Critical Communication Metrics

- Critical communication compliance – acknowledgment within 60 minutes
- Critical communication method – acknowledgment via push or phone call
- Critical communication time and money savings
 - Estimated to save annually: 4600 hours and \$200,000 for lab and 2500 hours and \$120,000 for nursing

Data: 2 months post implementation



83% Compliance by Electronic Notification (6,171 critical values)



Epic sent 5,978 alert notifications; 4,966 acknowledged within 10 minutes (average less than 2 minutes)



Lab made 1,206 phone calls; 82% of these were an escalation call



Lab workload decreased by 85%; >4000 fewer communications to nursing



Over 900 hours and ~\$45,000 saved (lab + nursing)

Lessons Learned: Room to Improve

- Optimize data collection tools
- Identify reasons why a push notification is not acknowledged or not sent
- Improve Lab monitoring of critical call worklist
- Continue to improve electronic compliance

Project Summary

- Implementation of a closed loop electronic process for critical lab results is a low risk and low-cost intervention.
- This workflow adds value and efficiencies to clinical workflows, saves money, and creates a safer patient care environment.
- This project demonstrated a successful integration of Epic's latest automated notification technology in a healthcare setting.

Questions?

e-mail: polskyt@chop.edu

