

Demonstrate the Value of Laboratory Test Information: Linking the Laboratory to other Healthcare Systems to Improve Patient Care

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Objectives

- Define informatics, its use and importance as a competency for all healthcare practitioners.
- Explain how the use of informatics with laboratory test information can improve patient outcomes.
- Identify two laboratory tests to link to other healthcare systems to improve patient outcomes.

Health Care Quality & Patient Safety

- “The degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge.”
IOM, Crossing the Quality Chasm, 2001
- “freedom from accidental injury: avoidance, prevention, and amelioration of adverse outcomes or injuries stemming from the process of care”
IOM, To Err is Human, 2000

Safe Laboratory Testing (Healthcare) is

- Safe
- Effective
- Efficient
- Timely
- Patient-centered
- Equitable

Competencies to Improve Patient Safety

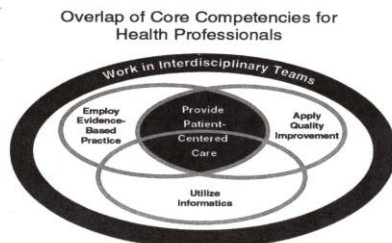


Figure 3-1 Relationship among core competencies for health professionals.

Source: *Health Professions Education, A Bridge to Quality*, Institute of Medicine, 2003

What is informatics?

- Informatics:
 - “science of processing data for storage and retrieval”; “information science”
 - “the collection, classification, storage, retrieval and dissemination of recorded knowledge”
 - www.merriam-webster.com/dictionary/informatics
- Medical informatics/Biomedical informatics:
 - “interdisciplinary field that studies and pursues the effective uses of biomedical data, information and scientific inquiry, problem solving and decision making, motivated by efforts to improve human health”
 - American Medical Informatics Association, www.amia.org/biomedical-informatics-core-competencies
- Bioinformatics
 - “the collection, classification, storage and analysis of biochemical & biological information using computers, especially as applied in molecular genetics and genomics”
 - <https://www.merriam-webster.com/dictionary/bioinformatics#medicalDictionary>

Transformations in Healthcare using Medical Informatics

- Manage information
- Communicate
- Improve delivery of healthcare
- Reduce errors
- Make decisions

Informatics to Manage Information

- System
 - Demographics, medical history, diagnosis, co-morbidities, allergies
 - Diagnostic Data—laboratory, radiology, other
 - Pharmacy Data—medications
 - Therapy Data—physical, occupational, chemotherapy
 - Documentation of out-patient visits

Informatics to Manage Information

- Laboratory
 - Manages the testing process
 - Test menu
 - Current requests for testing
 - Historical test results
 - Reference ranges
 - Quality control programs

Informatics to Communicate

- System
 - Electronic communication between patient & provider
 - Notification of test results
 - Reminders for appointments & other care
- Laboratory
 - Send test results to clinicians
 - Send test results to patients/clients
 - Remind patients/clients of upcoming laboratory test orders

Informatics to Improve the Delivery of Healthcare

- EHR/EMR
 - One record for inpatient and outpatient records
 - One record for test results, medications, appointments, notes
- LIS
 - Labeling
 - Identification of type of specimen
 - Worklists
 - Pending lists
 - Interface between instruments and reporting
 - Automatic verification

Informatics to Reduce Errors

- Standardize and automate processes, provide information, flagging alerts
- CPOE = computerized provider order entry
- Bar coding
- Delta checks
- Interface between instruments & LIS

Informatics to Make Decisions

- System
 - CPOE
- Laboratory
 - Reflex testing

Informatics to Make Decisions— Utilization for Hospitalized Patients

- CPOE
- Prior to implementing EHR, >95% hospitalized patients on internal medicine service had orders for daily laboratory tests
- Removed option of ordering daily recurring laboratory tests
- Outcome: ratio of laboratory tests performed/# of inpatients per day =
number of tests per patient per day

Source: Iturrate E, et al. Optimize Your Electronic Medical Record to Increase Value: Reducing Laboratory Utilization. *Am J of Medicine* (2016) 129, 215-220

Informatics to Make Decisions

- System—CPOE
- Results of most recent testing event displayed
- Recommendations for appropriate testing
- Cost of laboratory test displayed

Informatics to Make Decisions— Utilization for Hospitalized Patients

- Reduced utilization of:
 - PT/INR
 - Hepatic panel
 - Magnesium
 - Phosphorus
- Tests returned to pre-EHR institution
 - Basic metabolic profile
 - CBC

Source: Iturrate E, et al. Optimize Your Electronic Medical Record to Increase Value: Reducing Laboratory Utilization. *Am J of Medicine* (2016) 129, 215-220

Informatics to Make Decisions—Laboratory Utilization for Hospitalized Patients

- Outcomes:
 - Length of stay decreased
 - Mortality did not increase
 - Readmission rates decreased
- Surveyed clinicians:
 - Forgot to order tests evening before
 - Delay in receipt of laboratory test information
 - Required a change in their process
 - Decrease in clinician productivity

Source: Iturrate E, et al. Optimize Your Electronic Medical Record to Increase Value: Reducing Laboratory Utilization. *Am J of Medicine* (2016) 129, 215-220

Competency: Utilize Informatics

- What does utilize informatics competency entail?
- What do practitioners need to be able to do/understand/use with respect to utilize informatics?
 - Optimize information in the LIS
 - Incorporate decision analytic tools
 - Link laboratory test information with other systems

Competency: Utilize Informatics

- “Word processing, presentation & data analysis software”
- “Communicate using email, instant messaging, listservs, and file transfers”
- “Search, retrieve, manage and make decisions using electronic data from internal information databases and external online databases and the Internet”

Competency: Utilize Informatics

- “Understand security protections such as access control, data security, data encryption and directly address ethical and legal issues related to the use of information technology in practice”
- “Enhance education and access to reliable health information for patients”

Competency: Utilize Informatics— Specific to Medical Laboratory Science

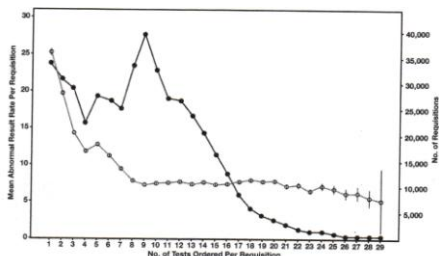
- Incorporate a statistical approach to data evaluation
 - Quality improvement studies
- Use electronic data to support decision & measure outcomes
 - Evidence-based practice

Use Informatics to Evaluate— Utilization Management

- Mean Abnormal Result Rate → indicates ordering selectivity
- If one test ordered, MARR = 25%
- If 9 or more ordered, MARR = 7%

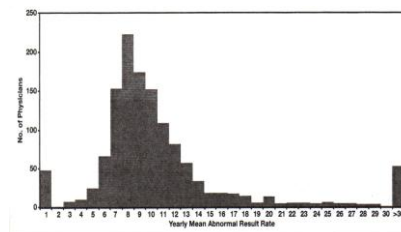
Source: Naugler CT et al. Mean Abnormal Result Rate, Proof of Concept of a New Metric for Benchmarking Selectivity in Laboratory Test Ordering. *Am J Clin Pathol.* 2016; 145: 568-573

Mean Abnormal Result Rate per Requisition vs Number of Tests Ordered per Requisition



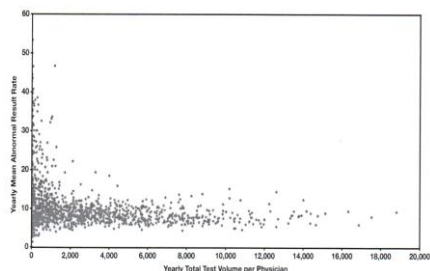
Source: Naugler CT et al. Mean Abnormal Result Rate, Proof of Concept of a New Metric for Benchmarking Selectivity in Laboratory Test Ordering. *Am J Clin Pathol.* 2016; 145: 568-573

Number of Physician vs Yearly Mean Abnormal Result Rate



Source: Naugler CT et al. Mean Abnormal Result Rate, Proof of Concept of a New Metric for Benchmarking Selectivity in Laboratory Test Ordering. *Am J Clin Pathol.* 2016; 145: 568-573

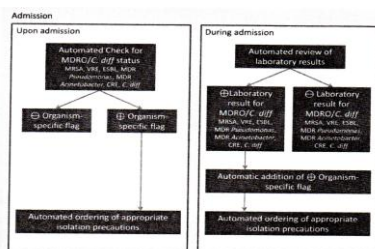
Yearly Mean Abnormal Result Rate vs Yearly Total Test Volume per Physician



Source: Nagler CT et al. Mean Abnormal Result Rate, Proof of Concept of a New Metric for Benchmarking Selectivity in Laboratory Test Ordering. *Am J Clin Pathol.* 2016; 145: 568-573

CONNECTING LABORATORY INFORMATION WITH OTHER SYSTEMS

Linking Microbiology Laboratory Data to Infection Control



Source: Quan KA. et al. Automated tracking and ordering of precautions for multidrug-resistant organisms. *American Journal of Infection Control.* 43(2015): 577-580

Linking Microbiology Laboratory Data to Infection Control

- Monitor laboratory test information & health system database
 - Review positive laboratory test results
 - Compare to multidrug resistant organism database
- Order contact precautions
 - Automatically order after positive laboratory test results finalized
- Discontinue precautions & inactivate pathogen flags
 - Identify past cases of multidrug resistant organisms to determine if eligible to be cleared

Source: Quan KA. Automated tracking and ordering of precautions for multidrug-resistant organisms. *American Journal of Infection Control.* 43(2015): 577-580

Trigger Tools to Identify Adverse Drug Events

- Institute for Healthcare Improvement Triggers:
- *Clostridium difficile* positive stool culture
- *aPTT* > 100 seconds
- *INR* > 6
- Glucose < 50 mg/dL
- Rising BUN or serum Creatinine (2x) over baseline

Source: Griffin FA, Resar RK. *IHI Global Trigger Tool for Measuring Adverse Events (Second Edition)*. IHI Innovation Series white paper. Cambridge, MA: Institute for Healthcare Improvement; 2009.

Linking Laboratory to Pharmacy— Send Results to Pharmacy

- Send positive *C.difficile* stool culture
- Send Glucose < 50 mg/dL
- Send rising BUN or serum Creatinine levels

Linking Laboratory to Hospital Risk Management System

- Others used to identify Adverse Events:
- *aPTT* > 100 seconds
- *INR* > 6
- Transfusion of blood or blood products
- Positive blood culture
- Any infection occurring after hospital admission

Source: Griffin FA, Resar RK. *IHI Global Trigger Tool for Measuring Adverse Events (Second Edition)*. IHI Innovation Series white paper. Cambridge, MA: Institute for Healthcare Improvement; 2009.

Does Your Laboratory Participate in Providing Evidence for Potential Adverse Events?

- If so, for which tests?
- If not, what tests would you consider setting up a flag, to warn of potential adverse event?

Linking Laboratory to Pharmacy

Category	Concept	Examples (Drug—Lab Pair)*	Special Role for the Computer/Linkage
Drug selection	1. Lab finding contraindicates drug	+ Pregnancy test—ACE inhibitor T INR—methylenedihydrochloride	Prevents prescription writing or dispensing
	2. Lab finding suggests indication for drug	T TSH—levothyroxine sodium T Cholesterol—lipid-lowering treatment	Generates timely reminders, tracking intervention
Dosing	3. Lab finding affecting drug dose	T Creatinine—digoxin, vancomycin Hyponatremia	Performs dose calculations based on age, sex, lab value, weight
	4. Drug requiring lab measure for titration	Anticoagulants—drug levels Liver enzymes—antibiotic, glitazones	Statistical process control dosing adjustment charts
Monitoring	5. Abnormal lab value signaling toxicity	↑ HCT, WBC—chemotherapeutic Calcium—WBC	Triggers alert, assesses likelihood
	6. Drug warranting lab value monitoring for toxicity	Amphotericin B—creatinine	Oversee scheduling of both baseline and serial monitoring tests
Lab interpretation	7. Drug labtesting or interfering with lab finding	Carbamazepine—free thyroxine Quinolones—color reactions urine opiate	Warns against/interprets false-positives and false-negatives
	8. Drug depending on response to lab finding	Insulin—↓ or ↑ glucose Penicillin—↑ WBC	Remits alert threshold for treated patients
Improvement	9. Drug toxicity/efficacy surveillance	Detects signals of previously undetected reaction (eg, hepatotoxicity)	Data mining of lab and drug data to generate new hypotheses of drug effects
	10. Quality oversight	Treatment delay after abnormal results (T TSH, T K ⁺ → blood culture) and initiation of appropriate treatment	Monitors time interval between lab testing and prescription change, adherence/compliance of lab monitoring

Abbreviations: ACE, angiotensin-converting enzyme; Ca, calcium; HCT, hemocrit; INR, international normalized ratio; K⁺, potassium; lab, laboratory; PT, prothrombin time; RPR, rapid plasma reagin; SGAP, serum urea nitrogen; TSH, thyrotrophic; WBC, white blood cell count.
*Plus sign indicates positive.

Source: Schiff GD. Linking Laboratory and Pharmacy. *Arch Intern Med* 2003; 163: 893-900

Linking Chemistry (HbA1c) Laboratory Data to Pharmacy System

- Evaluate diabetes care: changes in therapy based upon Hemoglobin A1c values
- 9 multispecialty groups submitted data – 4,818 patients
- HbA1c ≥ 8% for 27% of study population
- HbA1c ≥ 8% with no further testing for at least 90 days
- 54% of patients with actionable HbA1c did not have change in therapy initiated

Source: Wetzler et al. Linking pharmacy and laboratory data to assess the appropriateness of care in patients with diabetes. *Diabetes Care*. 2000; 23: 1637-1641

Linking Chemistry (TSH) Laboratory Data to Pharmacy System

- Uncover diagnostic errors
- Determine frequency of failed follow-up of ↑ TSH
- 2.6% & 2.1% unaware of hypothyroidism
- Often seen in ED or walk-in clinic, or while hospitalized
- Lack of follow-up appointment

Characteristic	2000	2001
Total TSH tests	22 076	24 524
Unique patients with TSH test results	17 467	19 299
Test results with TSH levels >20 mIU/L	1224 (6.9)	744 (2.8)
Unique patients with TSH levels >20 mIU/L	470 (2.7)	612 (2.7)
Patients		
Using levothyroxine	300 (32.0)	415 (67.1)
Not using levothyroxine	80 (17.0)	97 (15.8)
Using hyperthyroid medication	17 (3.6)	20 (3.3)
Who obtained prescription at outside pharmacy	17 (3.6)	34 (5.6)
Lost to follow-up or died	27 (5.7)	27 (5.3)
Aware of diagnosis without follow-up	4 (0.8)	2 (0.4)
Who missed diagnosis of hypothyroidism	12 (2.6)	11 (2.1)

Source: Schiff GD. Missed hypothyroidism diagnosis uncovered by linking laboratory and pharmacy data. *Arch Intern Med*. 2005; 165: 574-577

Linking Chemistry (HbA1c) Laboratory Data to Pharmacy System

- Implementation in 21st Century:
- Link to pharmacy
 - Send these test results to pharmacy system
 - Pharmacy identifies a list of patients with test values & links to their prescription information
- Alerts can be created between Pharmacy & EHR/EMR systems

Source: Wetzler et al. Linking pharmacy and laboratory data to assess the appropriateness of care in patients with diabetes. *Diabetes Care*. 2000; 23: 1637-1641

Linking Microbiology Laboratory Data to Pharmacy System

- Managing positive culture results for patients discharge from Emergency Department
- Urine, wound, and blood cultures
- All positive blood cultures—contact physician
- Phone patients with positive blood culture
- Review antimicrobial prescribed with sensitivity results
- Increased the rate of antimicrobial-related interventions
- Identified inappropriate anti-microbials prescribed for resistant organisms

Source: Davis LC et al. Pharmacist-driven antimicrobial optimization in the emergency department. *American Journal of Health System Pharmacists*. 2016; 73(supple 1): S49-S56

Linking Microbiology Laboratory Data to Pharmacy System

- How can information about positive blood (or other cultures) in hospitalized patients be more efficiently transmitted and acted upon more effectively?

Informatic Tool to Improve Warfarin Dosing

Post Operative Day	INR	Dose estimate (mg/d)
3	1.6	3.5
4	2.2	3.2
5	1.1	5.5

An alert is created if the new dose is > 10% than the weighted average of the previous two doses estimates.
Use of the author's equation would have estimated the dose for day 5 at 5.2 mg/d.

Source: Hyun G et al. Use of signals and systems engineering to improve the safety of warfarin initiation. *J Thromb Thrombolysis*. 2016; 42: 529-533.

Linking Microbiology Laboratory Data to Pharmacy System

- Average of 6 hours 35 minutes (range 1 hour 9 minutes to 21 hours 33 minutes) to administer new antibiotic upon notification of organism identification
- Longer delay during night shift (10 hours 33 minutes vs 4 hours 7 minutes)
- Pediatric cardiovascular, medical an surgical intensive care

Source: Grant MJC. et al. Clinician response time for positive blood culture results in a pediatric ICU. *Heart & Lung*. 2015; 44: 426-429

Informatic Tool to Improve Warfarin Dosing

- Genetics InFormatics Trial (GIFT) to prevent DVT
- Study participants: 65 years of age
- Received one month of warfarin therapy after elective hip or knee arthroplasty
- Focus for study: first 11 days of therapy
- Created an algorithm that uses previous INR value with current INR value to estimate new warfarin dose

Source: Hyun G et al. Use of signals and systems engineering to improve the safety of warfarin initiation. *J Thromb Thrombolysis*. 2016; 42: 529-533.

Informatics Too to Manage Warfarin Dosing

Source: www.WarfarinDosing.org

Informatics Tool to Manage



Source: www.WarfarinDosing.org

Errors in Testing Process in Primary Care

- Breakdowns in the following processes:
 - test ordering, reporting of results, patient notification
- Delays in diagnosis
 - Patients do not always receive test result information within 24 hours of physician receipt of test results
- Communication gaps within the Physician Office Practice
 - Lack of defined responsibilities as to who handles test reconciliation and communicating test results with patient
- Errors in judgment & cognition
 - Lead to test ordering errors & errors in test interpretation
- Lack of Patient Centeredness
 - Lack of a systematic & consistent method to inform patients of test results

Source: Smith ML. Evaluating the connections between primary care practice and clinical laboratory testing. *Arch Pathol Lab Med.* 2013; 137: 120-127.

Gaps in Laboratory Testing Process in Primary Care

- Test ordering processes
 - Paper copy of test orders
 - Electronic health record
 - Clinical flow sheets & guidelines
- Test tracking processes
 - Lack of tracking system for tests ordered and reconciliation method for orders & test results
- Communicating test results to patients
 - Multiple methods to contact patients
 - 25% of respondents—tell patients: no notification = normal test results

Source: West DR et al. *J Am Board Fam Med* 2014; 27: 796-803

Notification of Abnormal Laboratory Test Results in EMR

- Studied 4 alerts
 - HbA1c $\geq 15\%$
 - Positive Hepatitis C antibody
 - Prostate-specific antigen ≥ 15 ng/mL
 - TSH ≥ 15 mIU/L
- 10.2% of alerts were unacknowledged
- 6.8% lacked timely follow-up
- Alerts for new vs known diagnosis more likely to lack timely follow up (odds ratio 7.35 (4.16-12.97))

Source: Singh H. et al. Notification of abnormal lab test results in an electronic medical Record: do any safety concerns remain? *Am J of Med* 2010; 123: 238-244

Linking Laboratory Test Information to Emergency Department

- Emory University Hospitals
- aftER Care
- Automatically populates a list of pending tests
- Reviewed at end of each shift
- Clinician documents receipt of test results
- Contact patient with test results

Source: Fantz C. et al. No news is not always good news. *Clinical Laboratory News.* 2013 January

Informatics and Test Reporting

- Patient receives confirmation that laboratory test is performed
 - Send **ALL** laboratory test results to the patient

Wrap-Up

- Utilizing informatics to continue to improve patient safety with respect to laboratory testing
 - Infections, adverse drug reactions, chronic disease management
- Identify information that requires immediate action to create a linked system
 - Infections, adverse drug reactions, chronic disease management
- Create opportunities to improve the communication of laboratory test information
 - Emergency department, care transitions, patients
- Collaborate with colleagues in healthcare system
 - Pharmacists, clinicians, nurses

Resources

- Institute for Healthcare Improvement
www.ihp.org
- American Medical Informatics Association
www.amia.org
- Agency for Healthcare Quality and Research
www.ahrq.gov
- Cochrane Database of Systematic Reviews
www.cochranelibrary.com

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