Clinical Decision Support for Hematology Laboratory Utilization

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Disclosure

• I have no financial disclosures or conflicts of interest relevant to this presentation.
A case study in decision support

- Location: Petrified Wood National Park
- Problem: Visitors frequently removed petrified wood for souvenirs.
- Solution: Put up signs reading, “Your heritage is being vandalized every day by theft losses of petrified wood, mostly a small piece at a time.”
- Result: Theft increased from 5% to 8%.
- Conclusion: “Stealing petrified wood is a common and socially acceptable behavior.”


Images: nps.gov
Challenges in laboratory utilization

- 15-year meta-analysis of inappropriate laboratory testing
- 42 studies (1997-2012)

Zhi M et al. PLoS One 2013
Scope of the utilization problem

• 2014 American Board of Internal Medicine (ABIM) Foundation survey of physician ordering practices (n = 600, primary care and specialists)

Figure 1: Do you think the frequency of unnecessary tests and procedures in the health care system is a...

- Somewhat serious problem 44%
- Very serious problem 29%
- Not too serious problem 21%
- Not a problem at all 5%
- DK/REF 1%

Figure 4: Let’s say a patient came to you convinced he or she needed a specific test. You knew the test was unnecessary, but the patient was quite insistent. Would you:

- Order test/Order but advise against 53%
- Not sure 6%
- Refuse to order 40%
- Order 1%
- DK/REF 6%

choosingwisely.org
Motivations for overutilization

Figure 5: In your own practice, is this a reason you sometimes end up ordering an unnecessary test or procedure? IF YES: Is this a major reason or minor reason?
Total n = 600

- Malpractice concerns: 52%
- Just to be safe: 36%
- Want more information to reassure myself: 30%
- Patients insisting on test: 28%
- Wanting to keep patients happy: 23%
- Feel patients should make final decision: 13%
- Not enough time with patients: 13%
- Fee-for-service system: 5%
- New technology in practice: 5%

Defensive medicine
Patient autonomy

choosingwisely.org
Choosing Wisely initiative

• 2012 ABIM Foundation initiative

• >70 medical professional societies from all specialties provide 5-10 evidence-based recommendations on commonly overused tests and therapies
Choosing Wisely examples for lab utilization

1. Don’t transfuse more units of blood than absolutely necessary.

Each unit of blood carries risks. A restrictive threshold (7.0-8.0g/dL) should be used for the vast majority of hospitalized, stable patients without evidence of inadequate tissue oxygenation (evidence supports a threshold of 8.0g/dL in patients with pre-existing cardiovascular disease). Transfusion decisions should be influenced by symptoms and hemoglobin concentration. Single unit red cell transfusions should be the standard for non-bleeding, hospitalized patients. Additional units should only be prescribed after re-assessment of the patient and their hemoglobin value.

AABB

5. Don’t perform repetitive CBC and chemistry testing in the face of clinical and lab stability.

Hospitalized patients frequently have considerable volumes of blood drawn (phlebotomy) for diagnostic testing during short periods of time. Phlebotomy is highly associated with changes in hemoglobin and hematocrit levels for patients and can contribute to anemia. This anemia, in turn, may have significant consequences, especially for patients with cardiorespiratory diseases. Additionally, reducing the frequency of daily unnecessary phlebotomy can result in significant cost savings for hospitals.

Society of Hospital Medicine

9. Don’t test or treat for suspected heparin-induced thrombocytopenia (HIT) in patients with a low pre-test probability of HIT.

In patients with suspected HIT, use the “4T”s” score to calculate the pre-test probability of HIT. This scoring system uses the timing and degree of thrombocytopenia, the presence or absence of thrombosis, and the existence of other causes of thrombocytopenia to assess the pre-test probability of HIT. HIT can be excluded by a low pre-test probability score (4T’s score of 0-3) without the need for laboratory investigation. Do not discontinue heparin or start a non-heparin anticoagulant in these low-risk patients because presumptive treatment often involves an increased risk of bleeding, and because alternative anticoagulants are costly.

American Society of Hematology
Clinical decision support (CDS)

• **Definition**: “The use of information and communication technologies to bring relevant knowledge to bear on the health care and well-being of a patient” (Greenes RA ed. Clinical decision support: the road to broad adoption 2014)

• Requires expertise in several aspects of clinical informatics
  • Evidence-based medicine
  • Clinical decision-making
  • Health information technology, *e.g.* computerized provider order entry (CPOE) systems
  • Human-computer interaction

• **When implemented properly, CDS can be very effective in guiding appropriate laboratory utilization in many clinical scenarios.**
Common CDS tools to affect provider ordering behavior

<table>
<thead>
<tr>
<th>Ordering</th>
<th><strong>CDS intervention</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Order search menus</td>
</tr>
<tr>
<td></td>
<td>Order templates and instructions</td>
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<tr>
<td></td>
<td>Order sets</td>
</tr>
<tr>
<td></td>
<td>Order reflexes and cascades</td>
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<tr>
<td></td>
<td>Order alerts</td>
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<tr>
<td></td>
<td>• Interruptive</td>
</tr>
<tr>
<td></td>
<td>• Non-interruptive</td>
</tr>
<tr>
<td>Education</td>
<td>Electronic reporting and interpretation</td>
</tr>
<tr>
<td></td>
<td>Electronic references</td>
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<tr>
<td></td>
<td>Electronic feedback and benchmarking</td>
</tr>
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<td></td>
<td>• Individualized</td>
</tr>
<tr>
<td></td>
<td>• By department</td>
</tr>
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<td></td>
<td>• By institution</td>
</tr>
<tr>
<td>Diagnostics</td>
<td>Decision algorithms</td>
</tr>
<tr>
<td></td>
<td>• Within electronic health record</td>
</tr>
<tr>
<td></td>
<td>• On handheld/mobile devices</td>
</tr>
<tr>
<td></td>
<td>Predictive analytics/machine learning</td>
</tr>
</tbody>
</table>

Jackups R, Szymanski J, Persaud SP. *Int J Lab Hematol* 2017
Current state of CDS in the United States

- **Pharmacy**: widespread use
  - Dosing errors
  - Drug-drug and drug-allergy interactions

- **Federal mandates**
  - Meaningful Use (2012): financial incentives for use of CDS tools
  - Protecting Access to Medicare Act (2014): Certified CDS required for reimbursement of certain outpatient imaging studies by 2018

- **Laboratory**: only beginning to be realized

<table>
<thead>
<tr>
<th>Stage 1</th>
<th>Stage 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Implement one clinical decision support rule relevant to specialty or high clinical priority along with the ability to track compliance that rule</td>
</tr>
<tr>
<td>Measure</td>
<td>Implement one clinical decision support rule</td>
</tr>
</tbody>
</table>

- Use clinical decision support to improve performance on high-priority health conditions

1. Implement 5 clinical decision support interventions related to 4 or more clinical quality measures, if applicable, at a relevant point in patient care for the entire EHR reporting period.

2. The EP, eligible hospital, or CAH has enabled the functionality for drug-drug and drug-allergy interaction checks for the entire EHR reporting period.

Meaningful Use CDS objectives
CDS applications for laboratory utilization

- Blood utilization
- Complex diagnostic algorithms (e.g. flow cytometry)
- Unnecessary duplicate testing
- Misordering of tests with similar names (e.g. cryoglobulins vs. cold agglutinins)
- Laboratory monitoring of specific drugs (e.g. anticoagulants)
Order sets/bundles

Order Set: Hypercoagulability Lab Order Bundle

Order Items:
- Protein C Activity - Routine
  - Protein S Free - Routine
  - Activated Protein C Resistance V Assay - Routine
  - Lupus Anticoagulant Panel with Reflexes - Routine
  - Cardiolipin Antibodies IgG and IgM - Routine
  - Homocysteine - Routine

Neurology Rapid Dementia Orders [0 orders of 21 are selected]

Provider Pager: 
Check to fill your pager number: 

Neurology Attending Physician: 

Labs:
- RRR Qual
- Methylmalonic Acid, Quant
- Heavy Metals Ur Random
- Nuclear Antibody Qual
- HIV 1/2 Ab + p24 Ag
- Homocysteine
- ESR
- Neutrophil Cytoplasmic Ab Qual

Consults:
- Neurology MD Consult

- Thyroid Cascade
- Ammonia Level
- C Reactive Protein
- ENA Screen
- Thyroid Peroxidase Ab
- Ammonia Level
- Serum Protein Electrophoresis Reflex
- Complete Paraneoplastic Panel
- Vitamin B12 Level
- Ceruloplasmin
- Rheumatoid Factor Quan
- Extra Slide for Physician Review
Heparin-induced thrombocytopenia (HIT) testing order at Univ. Iowa (image by Bradley Ford)

Reduces HIT ELISA testing by 49%. (Samuelson BT et al. Thromb Res. 2015)
Order reflexes/cascades

Preop evaluation for surgical patients

- Test PT/INR and PTT
  - Normal PTT: No further testing
  - Prolonged PTT:
    - Reflex to lupus anticoagulant (LA) test
      - Positive: No further testing
      - Negative or indeterminate: LMR chart review to investigate prolonged PTT
    - Interfering anticoagulant: No further testing

CPAP aPTT algorithm
Electronic feedback and benchmarking

You are Surgeon E.

A higher percentage in the rightmost column of the table (and a higher line on the plot) indicate better compliance with the evidence-based guideline of transfusing RBCs after hip surgery for Hgb < 8 g/dL.

<table>
<thead>
<tr>
<th>Surgeon</th>
<th>Hip Patients (n)</th>
<th>Postop RBCs meeting FOCUS guideline n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>26</td>
<td>47/75 (63%)</td>
</tr>
<tr>
<td>D</td>
<td>14</td>
<td>48/82 (59%)</td>
</tr>
<tr>
<td>C</td>
<td>6</td>
<td>20/44 (45%)</td>
</tr>
<tr>
<td>B</td>
<td>10</td>
<td>14/37 (38%)</td>
</tr>
<tr>
<td>A</td>
<td>14</td>
<td>6/27 (22%)</td>
</tr>
</tbody>
</table>

Feedback report of compliance with transfusion thresholds by orthopedic surgeons (Trial of Feedback on Blood Use, Kaufman R et al. 2013)
Mobile device diagnostic tools

itunes.apple.com (accessed 3/15/17)
Order alerts (a.k.a. “best practice alerts”)  

- Messages that appear in the CPOE in response to order provider activity in an effort to direct/re-direct ordering behavior  
  - Non-interruptive: does not interfere with provider workflow  
    - Infobutton (HL7: context-aware knowledge retrieval application)  
  - Interruptive: prevents further action in workflow until addressed  
    - “Soft stop”: may be bypassed by provider via button clicks or acknowledgement within CPOE  
    - “Hard stop”: cannot be bypassed within CPOE
Order alert (soft stop) example

- **Objective Data**: Patient has existing CBC Express on May-12-2015 19:00 that is Pending Collection. No previous results found.


- **Provider Acknowledgement Comment**: Hemorrhage or hemolysis, Post-transfusion monitoring, Hemodynamic instability, New infection

- Acknowledge when seen, Acknowledge all on Proceed

[Image of a user interface showing an alert with serial blood count information and acknowledgments options.]
Studies of duplicate test alerts

• Multiple studies have investigated the use of interruptive alerts to prevent unnecessary duplicate test orders.
  • Comparison of hard stop and soft stop for duplicate testing within 24 hours
  • Hard stop for duplicate testing within a test-specific clinically relevant window of time (>24 hours)
  • Soft stop for duplicate testing within an inpatient admission
Comparison of hard vs. soft stop

- Retrospective review of two types of alerts to prevent duplicate ordering of >1,000 lab tests deemed rarely necessary within 24 hours
  - **Hard stop** at main campus of Cleveland Clinic
  - **Soft stop** at 7 regional hospitals in the Cleveland Clinic Health System
- Hard stop could only be bypassed by direct contact with laboratory staff
- Alerts compared over 12 months

Results

Hard stop
5,405/5,858 averted
$94,225 saved
$16.08/alert

Soft stop
5,669/12,990 averted
$45,681 saved
$3.52/alert

$p < 0.0001$
Hard stop for long-interval duplicate testing

- Retrospective review of a hard stop at a 900-bed Dutch teaching hospital and reference center to bar unnecessary duplicate lab testing

- 44 tests selected, each given an allowable duplicate period based on:
  - Approximate rate of change in analyte levels within a patient over time
  - Assumed frequency with which clinicians require lab results for patient care
  - Logistical needs of impacted clinics

- Rates of barred tests evaluated over 12 months after a 21-month pilot period

Results for selected tests

<table>
<thead>
<tr>
<th>Test name</th>
<th>Interval</th>
<th>% barred</th>
<th>€ saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cholesterol</td>
<td>14 d</td>
<td>0.88</td>
<td>882</td>
</tr>
<tr>
<td>Folate</td>
<td>30 d</td>
<td>0.45</td>
<td>564</td>
</tr>
<tr>
<td>HbA1C</td>
<td>40 d</td>
<td>0.46</td>
<td>1,360</td>
</tr>
<tr>
<td>Vitamin B12</td>
<td>30 d</td>
<td>0.50</td>
<td>1,088</td>
</tr>
<tr>
<td><strong>All tests</strong></td>
<td></td>
<td><strong>0.56</strong></td>
<td><strong>7,766</strong></td>
</tr>
</tbody>
</table>
Once-per-admission alert

- **Soft stop** alert at Barnes-Jewish Hospital (St. Louis, MO) to prevent unnecessary duplicate testing
- Implemented Sept 2012; data collected through Sept 2016
- Originally 5 tests (HbA1C, lipid panel, HIV Ab, ferritin, TSH), now 20

<table>
<thead>
<tr>
<th>This patient already has a Thyroid Stimulating Hormone ordered.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status: Results Received</td>
</tr>
<tr>
<td>Last Updated: 05/24/2016 23:14</td>
</tr>
<tr>
<td>Thyroid Stimulating Hormone: 0.81 mclUnit/mL</td>
</tr>
<tr>
<td>[0.30-4.20]</td>
</tr>
<tr>
<td>Interpretive Data</td>
</tr>
<tr>
<td>Hyperthyroid: &lt;0.1 mclUnit/mL Hypothyroid: &gt;12.0 mclUnit/mL</td>
</tr>
</tbody>
</table>
Results (Sept 2012 – Sept 2016)

- Total alert activations: 51,367
- Total unique patients: 19,426 (2.6 alerts/patient)
- Order providers: 3,824 (13.4 alerts/provider)

Top decile (9.6%) of users account for 50% of alerts. Physicians make up 79% of top decile, but only 34% of all users.
Overall success rates

- 30% of alerts “changed practice” (*i.e.* resulted in cancellation of test)

<table>
<thead>
<tr>
<th>Test</th>
<th># Alerts</th>
<th>% Changed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferritin Level</td>
<td>3,375</td>
<td>24.3</td>
</tr>
<tr>
<td>Folate Level</td>
<td>1,478</td>
<td>25.1</td>
</tr>
<tr>
<td>Hemoglobin A1C</td>
<td>8,462</td>
<td>25.2</td>
</tr>
<tr>
<td>Protein C Activity</td>
<td>78</td>
<td>25.6</td>
</tr>
<tr>
<td>Protein S Free</td>
<td>79</td>
<td>26.6</td>
</tr>
<tr>
<td>Iron Battery</td>
<td>3,311</td>
<td>27.4</td>
</tr>
<tr>
<td>Lipid Panel</td>
<td>6,583</td>
<td>28.4</td>
</tr>
<tr>
<td>HIV 1/2 Ab + p24 Ag</td>
<td>1,517</td>
<td>29.3</td>
</tr>
<tr>
<td>Vitamin B12 Level</td>
<td>2,688</td>
<td>30.4</td>
</tr>
<tr>
<td>Thyroid Stimulating Hormone</td>
<td>7,681</td>
<td>31.0</td>
</tr>
<tr>
<td>HIV 1-2 Ab</td>
<td>809</td>
<td>31.9</td>
</tr>
<tr>
<td>Clostridium Difficile Toxin</td>
<td>11,764</td>
<td>32.9</td>
</tr>
<tr>
<td>Acute Hepatitis Panel</td>
<td>1,387</td>
<td>33.9</td>
</tr>
<tr>
<td>Cardiolipin Antibodies IgG and IgM</td>
<td>143</td>
<td>35.7</td>
</tr>
<tr>
<td>Toxins Clostridium Difficile A and B</td>
<td>243</td>
<td>35.8</td>
</tr>
<tr>
<td>Nuclear Antibody Qual</td>
<td>427</td>
<td>37.5</td>
</tr>
<tr>
<td>G6PD Qual</td>
<td>56</td>
<td>50.0</td>
</tr>
<tr>
<td>Vitamin D, 25OH</td>
<td>549</td>
<td>51.9</td>
</tr>
<tr>
<td>Activated Protein C Resistance</td>
<td>177</td>
<td>56.5</td>
</tr>
<tr>
<td>Lupus Anticoagulant Panel</td>
<td>494</td>
<td>60.7</td>
</tr>
<tr>
<td>CPAP aPTT Algorithm</td>
<td>66</td>
<td>63.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>User role</th>
<th># Alerts</th>
<th>% Changed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physician</td>
<td>30,758</td>
<td><strong>32.0</strong>*</td>
</tr>
<tr>
<td>Registered nurse</td>
<td>15,855</td>
<td><strong>22.1</strong>*</td>
</tr>
<tr>
<td>Nurse practitioner</td>
<td>3,261</td>
<td>43.8</td>
</tr>
<tr>
<td>Other</td>
<td>1,493</td>
<td>34.2</td>
</tr>
</tbody>
</table>

*p < 0.0001*
Success rate over time

<table>
<thead>
<tr>
<th>Month</th>
<th>Cancel rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>July-Aug</td>
<td>35.5%</td>
</tr>
<tr>
<td>All others</td>
<td>28.9%</td>
</tr>
</tbody>
</table>

*p < 0.0001*
Guidelines for effective CDS

The Five Rights of CDS

- The right information
- To the right person
- In the right CDS intervention format
- Through the right channel
- At the right time in the workflow

Sirajuddin AM et al. *J Healthc Inf Manag* 2009

The Ten Commandments for Effective CDS

- Speed is everything.
- Anticipate needs and deliver in real time.
- Fit into the user’s workflow.
- Little things can make a big difference.
- **Recognize that physicians will strongly resist stopping.** (Can lead to alert fatigue.)
- Changing direction is easier than stopping.
- **Simple interventions work best.**
- Ask for additional information only when you really need it.
- **Monitor impact, get feedback, and respond.**
- Manage and maintain your knowledge-based systems.

Bates DW et al. *J Am Med Inform Assoc* 2003
Additional recommendations for effective CDS

- CDS initiatives should be accompanied by **administrative support, stakeholder buy-in, and extensive education** before go-live.
- Multiple outcome measures should be analyzed.
  - Direct measures: user response rate, user satisfaction
  - Process measures: test volume, cost savings
  - Clinical measures: length-of-stay, adverse events
- Expect the unexpected.
  - Clever workarounds by ordering providers
  - Unintended consequences due to poor CDS design
Back to petrified wood...

- Behavioral semiotic time-course study of 2655 visitors to Petrified Wood National Park
- Signage was randomized, locations baited with loose pieces of wood

<table>
<thead>
<tr>
<th>Message type</th>
<th>Message text</th>
<th>Theft (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative command</td>
<td>“Please don’t remove the petrified wood from the park.”</td>
<td>1.67</td>
</tr>
<tr>
<td>Positive command</td>
<td>“Please leave petrified wood in the park.”</td>
<td>5.33</td>
</tr>
<tr>
<td>Negative descriptive</td>
<td>“Many past visitors have removed the petrified wood from the park, changing the state of the Petrified Forest.”</td>
<td>7.92</td>
</tr>
<tr>
<td>Positive descriptive</td>
<td>“The vast majority of past visitors have left the petrified wood in the park, preserving the natural state of the Petrified Forest.”</td>
<td>5.00</td>
</tr>
</tbody>
</table>

**Conclusion:** Short, direct messages work best.  
Cialdini et al. *Social Influence* 2006
Conclusions

• Clinical decision support offers many avenues to improve laboratory test utilization.

• Care must be taken to select the right CDS intervention to achieve the most success.
  • Hard stop alerts tend to be more successful than soft stops, but may not be accepted by clinicians.

• There is vast potential for further research into the value of CDS for laboratory utilization.