The Delta Check in Action: 
*Causes and consequences of discrepant laboratory results*

Joely Straseski, PhD, DABCC, FACB  
Assistant Professor of Pathology  
Medical Director, Endocrinology  
Co-Medical Director, Automated Core Laboratory  
ARUP Laboratories and University of Utah
Outline: The Delta Check in Action

- Definitions
- Causes
- Institution
- Implications & Investigation Tips
Initiation of a Discrepant Results Policy: One hospital’s experience: A Sentinel Event

- Delta check alert occurred on several chemistry and hematology results for an individual patient
  - “Delta MCV” called to RN on floor; RN acknowledged receipt; heme results released to the patient chart
  - Delta chemistry results were confirmed; results released to the patient chart
- Type and cross was performed for transfusion
  - Patient had no previous ABO history for comparison
- Patient was given 2 units of blood and experienced a transfusion reaction

What happened?

The wrong patient was drawn...
Delta Check: Definition

- Difference between a patient’s *present* laboratory result and their *previous* result exceeds a predefined limit within a predefined length of time
  - First described by Nosanchuk and Gottmann in 1974
  - Computers first used for delta check identification in 1975
  - Addresses errors that are not detectable with other methods of quality control; assesses preanalytical, analytical, postanalytical errors

- Two main goals...identify:
  - Changes in patient condition
  - Sample quality issues / patient misidentification

Delta Check: Examples

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
<th>Absolute Difference</th>
<th># of Days b/t Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea Nitrogen</td>
<td>&lt; 50 mg/dL</td>
<td>10 mg/dL</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>&gt; 50 mg/dL</td>
<td>20%</td>
<td>2</td>
</tr>
<tr>
<td>Sodium</td>
<td>All</td>
<td>13 mEq/L</td>
<td>3</td>
</tr>
<tr>
<td>Calcium</td>
<td>&lt; 8 mg/dL</td>
<td>0.8 mg/dL</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>&gt; 8 mg/dL</td>
<td>1.0 mg/dL</td>
<td>2</td>
</tr>
<tr>
<td>MCV</td>
<td>All</td>
<td>5 fL</td>
<td>0</td>
</tr>
</tbody>
</table>

• **Actual limits will vary by analyze and institution**
Why bother using Delta Checks?

- Identify possible patient-specific errors
- Predictive value for detecting true specimen errors: between 0.4 and 6% \(^1,2\)
  - >75% can be attributed to true changes in the patient’s medical condition \(^2-5\)
  - Therefore, goal is to minimize false positives
- Early error identification: patient care and safety \(^2\)
  - Errors: incorrect drug dosing, anticoagulation therapy, cardiac intervention, blood transfusion, etc.
- Alert providers; fluctuations may indicate need for medical intervention

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Causes of Discrepant Results:

**Pre-analytical variation**
- Patient identification
- Specimen collection
- Post-collection

**Analytical variation**
- Instrument
- Method

**Biological variation**
- Rhythmic changes
- Lifespan
- Treatment
Causes of Discrepant Results:

<table>
<thead>
<tr>
<th>Pre-analytical variation</th>
<th>Analytical variation</th>
<th>Biological variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Patient identification</td>
<td>• Instrument</td>
<td>• Rhythmic changes</td>
</tr>
<tr>
<td>• Specimen collection</td>
<td>• Method</td>
<td>• Lifespan</td>
</tr>
<tr>
<td>• Post-collection</td>
<td></td>
<td>• Treatment</td>
</tr>
</tbody>
</table>
Pre-Analytical Variation: Identification

• **Definition: “Mislabeled”**
  – Joint Commission National Patient Safety Goals:
    – Minimum two unique patient identifiers
    – Label samples in front of patient
  – Mislabeled: One or more identifiers are incorrect
    – Wrong patient label; tube label does not match paperwork or electronic order; contradictory labels on one tube
  – Major issue in transfusion medicine
  – Difficult to detect and assess—often go unreported
Pre-Analytical Variation: Identification

- **Definition:** “Misidentified”
  - WBIT = Wrong Blood in Tube
  - Possible causes:
    - NICU, ER, geriatric populations
    - Sleeping, uncommunicative patients
    - Language barriers
    - Fraud
    - Identical names
    - Multiple births

- Majority of errors (10/17) associated with invasive procedures are due to patient misidentification
  (Howanitz et al., Arch Pathol Lab Med 2002)
Pre-Analytical Variation: Identification

- Patient identification error statistics:
  - In transfusion medicine = 0.05% of specimens
  - In general laboratory = 1% - 7.4% of specimens
  - In stat laboratory = 8.8% of specimens
- WBIT rate = 0.03-0.04%, up to 8.8%
- Smaller hospitals have higher error rates
- Extrapolated data: 160,000 adverse events/yr due to misidentification
- Pre-verification error rate = 85.5%
  Post-verification error rate = 14.5%

### Pre-Analytical Variation: Collection

<table>
<thead>
<tr>
<th>Source of Variation:</th>
<th>Effect on Laboratory Result(s):</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV fluid dilution</td>
<td>False increase in corresponding analytes, dilution of other analytes</td>
</tr>
<tr>
<td>Serum vs. plasma</td>
<td>Fibrinogen causes differences in total protein levels; clot formation causes release of K⁺ from platelets; extremely high WBC counts increase K⁺ from cell leakage</td>
</tr>
<tr>
<td>Order of blood tube collection</td>
<td>Contamination of subsequent tubes with anticoagulant, preservatives or other additives. Red top (non-additive) tube should be used as waste/discard tube.</td>
</tr>
<tr>
<td>Improper anticoagulant</td>
<td>EDTA: increased K⁺, decreased Ca²⁺, Mg²⁺, alk phos</td>
</tr>
<tr>
<td></td>
<td>Sodium citrate: increased Na⁺, anion gap</td>
</tr>
<tr>
<td></td>
<td>Heparin: Inhibits PCR reactions</td>
</tr>
<tr>
<td></td>
<td>Others: Increase in predominant anticoagulant component</td>
</tr>
<tr>
<td>Long tourniquet time</td>
<td>Concentration of analytes, false increase in K⁺, ammonia, lactate</td>
</tr>
<tr>
<td>Contrast agents</td>
<td>Some gadolinium agents falsely decrease Ca²⁺</td>
</tr>
<tr>
<td>Serum separator tubes (SST)</td>
<td>Serum separator gel may absorb small molecules such as drugs. Red top tubes recommended for therapeutic drug monitoring and other drug levels.</td>
</tr>
</tbody>
</table>
Pre-Analytical Variation: Post-collection

• Sample transport:
  – Timing: off-site blood drawing, delayed centrifugation, WBC glucose utilization, leakage of RBC contents
  – Temperature: Arterial blood gases, cryoglobulin, K⁺, lactic acid, ammonia
  – Light exposure: bilirubin, vitamins, porphyrins
  – Tube closure: pH, pCO₂, iCa²⁺, acid phos, ethanol
  – Pneumatic tubes: may cause RBC damage
  – Note: hemolysis is masked in whole blood samples—spin to confirm

• Centrifugation: Timely separation of serum and cells (w/i 2 hrs)
  – Delayed separation affects glucose, K⁺, LD, ammonia, phosphate
  – Excessive spins: hemolysis due to RBC membrane damage; K⁺, enzymes affected

• Storage
  – Labile analytes must be frozen, avoid excessive freeze-thaw cycles
Laboratory Mistakes:

Hospital study:
- 46% preanalytical
- 7% analytical
- 47% postanalytical

Blood bank study:
- 41% preanalytical
- 4% analytical
- 55% postanalytical

The majority of handling errors take place outside of the laboratory.

Therefore, laboratory-specific quality indicators and flags are even more important to ensure patient safety.
Causes of Discrepant Results:

### Pre-analytical variation
- Patient identification
- Specimen collection
- Post-collection

### Analytical variation
- Instrument
- Method

### Biological variation
- Rhythmic changes
- Lifespan
- Treatment
Analytical Variation:

• Instrument-specific issues:
  – Probe or pipettor errors
  – Variation in reagent volumes, delivery
  – Air bubbles
  – Calibration

• Operator- or method-specific issues:
  – Dilution errors, improper mixing
  – pH, temperature
  – Reagent, lot changes

• This is where the majority of our investigative power lies (QC, imprecision, bias, etc.).
Causes of Discrepant Results:

**Pre-analytical variation**
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- Post-collection

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- Instrument
- Method

**Biological variation**
- Rhythmic changes
- Lifespan
- Treatment
Biological Variation: Overview

- **Main goal of the human body = Homeostasis!**
  - Avoid fluctuations

- **Tightly regulated:**
  - Alkaline phosphatase, sodium, calcium, RBC indices (MCV, RDW), hemoglobin, pH

- **Less stringently regulated:**
  - Iron, bicarbonate, lactate, albumin
## Biological Variation: Sources

### Physiological Sources of Variation

<table>
<thead>
<tr>
<th>Controllable</th>
<th>Uncontrollable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posture</td>
<td>Gender, age, and race</td>
</tr>
<tr>
<td>Immobilization</td>
<td>Rhythmic influences, such as circadian, circannual, and menstrual</td>
</tr>
<tr>
<td>Exercise</td>
<td>Fever</td>
</tr>
<tr>
<td>Diet</td>
<td></td>
</tr>
<tr>
<td>Transfusion</td>
<td></td>
</tr>
<tr>
<td>Environment (altitude, geographical location)</td>
<td></td>
</tr>
</tbody>
</table>

### Type of Change | Timeframe | Examples |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Circadian</td>
<td>Once per day</td>
<td>Hormones (cortisol, growth hormone)</td>
</tr>
<tr>
<td>Ultradian</td>
<td>&gt; Once per day</td>
<td>Pituitary and hypothalamic hormones</td>
</tr>
<tr>
<td>Infradian</td>
<td>&gt; One day</td>
<td>Menstrual cycle (FSH, LH)</td>
</tr>
<tr>
<td>Circannual</td>
<td>Yearly; seasonally</td>
<td>Vitamin D, LD, cholesterol</td>
</tr>
</tbody>
</table>
Biological Variation: Changes Over the Lifespan

• Delta check limits may change with patient age
  – MCV elevations in neonates
  – Creatinine decreases with age, urea increases

• Lifestyle changes cause variation
  – Nutritional status
  – Activity level
## Biological Variation: Treatment

**Treatment Examples:**

<table>
<thead>
<tr>
<th>Treatment Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV fluids</td>
</tr>
<tr>
<td>Total parenteral nutrition (TPN; feeding via IV)</td>
</tr>
<tr>
<td>Chemotherapeutics</td>
</tr>
<tr>
<td>Dialysis</td>
</tr>
<tr>
<td>Surgery</td>
</tr>
<tr>
<td>Organ transplantation</td>
</tr>
<tr>
<td>Other medications</td>
</tr>
</tbody>
</table>
Outline: The Delta Check in Action

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How are delta check limits derived?

A. Population distribution
   – Identify representative individuals; gather serial results
   – Determine delta values between serial specimens
   – Determine frequencies (similar to reference interval determinations)
   – Establish institute-specific limits

B. Biological variation
   – Preanalytical, analytical, postanalytical, biological
   – Use reference change value (RCV) to assess significance

C. Experience and adjustment over time

D. Combination of the above approaches
Choosing Delta Check Limits (1):

• Identify “goal” of a detected failure
  – What are you trying to identify?
    • Sample integrity issues, misidentified samples, changes in patient condition
  – Balance between proper error identification and excessive alerts/investigations

• Some analytes are more useful as delta checks than others:
  – Little day-to-day variation
  – Low Reference Change Value
  – Low Index of Individuality
    • Creatinine, alk phos, urea, bilirubin, MCV
Choosing Delta Check Limits (2):

• Different rules for different populations
  – Neonates, oncology, transplant, outpatients...

• Absolute, percentage, and/or rate change
  – May vary by analyte concentration
  – Increases in values may have different implications than decreases
  – Rate changes (Lacher and Connelly, Clin Chem 34:1966(1988))
    – Delta rate change = Delta difference ÷ Delta time interval
A question of timing...

General Rule: Correlation between results decreases as time intervals increase

Time Adjusted Sensitivity Analysis: A New Statistical Test for the Optimization of Delta Check Rules

Maureen L. Sampson, BS   Nadja N. Rehak, PhD   Lori J. Sokoll, PhD   Mark E. Ruddel, MS
Gregory A. Gerhardt, MS   Alan T. Remaley, MD, PhD

VOLUME 30, NUMBER 1-2, SPRING-SUMMER 2007   JOURNAL OF CLINICAL LIGAND ASSAY

• Goal: optimizing delta check rules, to increase sensitivity and specificity
• 20 general chemistry analytes
• 1-28 days apart; total n (2 sites) = 62,640
A question of timing...

- Time-Adjusted-Sensitivity Score (TAS) =
  \[ \text{Sensitivity} \times \text{relative cumulative frequency} \]  
  \[ \text{(repeat ordering frequency)} \]

- Peak TAS determines optimal time interval between measurements

- Findings:
  - Creatinine: high R^2 over time, slow ordering pattern, high TAS over time
  - Enzymes: peak TAS > 25%; prior to day 5
  - Electrolytes: lower peak TAS
  - Glucose, Mg: TAS < 2%; delta checks not helpful

### TABLE 2 Optimum TAS score parameters

<table>
<thead>
<tr>
<th>Analyte</th>
<th>± Rule</th>
<th>Unit</th>
<th>Opt. Day</th>
<th>Day range*</th>
<th>Sens%</th>
<th>Spec%</th>
<th>RCF</th>
<th>Max TAS%</th>
</tr>
</thead>
<tbody>
<tr>
<td>CK</td>
<td>0.50</td>
<td>log (IU/L)</td>
<td>1</td>
<td>1–3</td>
<td>48.6</td>
<td>99.0</td>
<td>0.882</td>
<td>42.8</td>
</tr>
<tr>
<td>DBIL</td>
<td>0.65</td>
<td>log (μmol/L)</td>
<td>5</td>
<td>2–5</td>
<td>47.7</td>
<td>99.0</td>
<td>0.889</td>
<td>42.4</td>
</tr>
<tr>
<td>TBIL</td>
<td>0.54</td>
<td>log (μmol/L)</td>
<td>3</td>
<td>2–10</td>
<td>37.8</td>
<td>99.0</td>
<td>0.907</td>
<td>34.3</td>
</tr>
<tr>
<td>ALT</td>
<td>0.71</td>
<td>log (IU/L)</td>
<td>4</td>
<td>2–17</td>
<td>35.4</td>
<td>98.9</td>
<td>0.943</td>
<td>33.3</td>
</tr>
<tr>
<td>LDH</td>
<td>0.27</td>
<td>log (IU/L)</td>
<td>1</td>
<td>1–3</td>
<td>54.8</td>
<td>98.8</td>
<td>0.524</td>
<td>7</td>
</tr>
<tr>
<td>ALP</td>
<td>0.43</td>
<td>log (IU/L)</td>
<td>5</td>
<td>2–10</td>
<td>28.9</td>
<td>99.0</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>ALB</td>
<td>13.00</td>
<td>g/L</td>
<td>5</td>
<td>2–14</td>
<td>26.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BUN</td>
<td>125.00</td>
<td>percent</td>
<td>2</td>
<td>1–4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TP</td>
<td>23.00</td>
<td>g/L</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16.1</td>
</tr>
<tr>
<td>CREAT</td>
<td>47.00</td>
<td>percent log</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>14.1</td>
</tr>
<tr>
<td>AST</td>
<td>0.74</td>
<td>log (IU/L)</td>
<td></td>
<td></td>
<td>7</td>
<td></td>
<td></td>
<td>13.5</td>
</tr>
<tr>
<td>Cl</td>
<td>14.00</td>
<td></td>
<td>3</td>
<td></td>
<td>14.7</td>
<td>98.9</td>
<td>0.907</td>
<td>13.4</td>
</tr>
<tr>
<td>Na</td>
<td></td>
<td></td>
<td></td>
<td>2–3</td>
<td>9.4</td>
<td>98.8</td>
<td>0.948</td>
<td>8.9</td>
</tr>
<tr>
<td>Ca</td>
<td></td>
<td></td>
<td>2</td>
<td>2–5</td>
<td>8.0</td>
<td>99.0</td>
<td>0.909</td>
<td>7.3</td>
</tr>
<tr>
<td>PO4</td>
<td></td>
<td>percent</td>
<td>2</td>
<td>2–5</td>
<td>7.7</td>
<td>99.0</td>
<td>0.825</td>
<td>6.3</td>
</tr>
<tr>
<td>K</td>
<td>2.10</td>
<td>mmol/L</td>
<td>2</td>
<td>2–3</td>
<td>5.0</td>
<td>99.0</td>
<td>0.910</td>
<td>4.6</td>
</tr>
<tr>
<td>CO2</td>
<td>12.00</td>
<td>mmol/L</td>
<td>4</td>
<td>2–7</td>
<td>8.2</td>
<td>98.9</td>
<td>0.528</td>
<td>4.3</td>
</tr>
<tr>
<td>UA</td>
<td>0.50</td>
<td>mmol/L</td>
<td>2</td>
<td>1–2</td>
<td>3.2</td>
<td>99.0</td>
<td>0.852</td>
<td>2.7</td>
</tr>
<tr>
<td>Mg</td>
<td>1.20</td>
<td>mmol/L</td>
<td>21</td>
<td>4–28</td>
<td>1.8</td>
<td>98.9</td>
<td>1.000</td>
<td>1.8</td>
</tr>
<tr>
<td>GLU</td>
<td>14.20</td>
<td>mmol/L</td>
<td>7</td>
<td>2–28</td>
<td>1.3</td>
<td>99.0</td>
<td>0.997</td>
<td>1.3</td>
</tr>
</tbody>
</table>

**Ideal time range = 2-5 days**

Reference Change Value (RCV):

- “Is the difference between 2 values actually significant?”

- May use to determine delta check limits
  - Analytical and biological variation
  - Determines the allowable change in serial measurements

- “Significant Change Value”
  - 2010 convocation of experts on laboratory quality
    (Cooper et al., CCLM 49:793(2011))
Reference Change Value (RCV):

\[ RCV = 2^{0.5} \times Z \times (CV_A^2 + CV_I^2)^{0.5} \]

- **Z** = For 2 tailed analyses:
  - 1.96 at 95% probability ("significant");
  - 2.58 at 99% probability ("highly significant")

- **CV_A** = analytical variation (from QC)
- **CV_I** = intraindividual variation (from literature or [http://www.westgard.com/biodatabase1.htm](http://www.westgard.com/biodatabase1.htm))
RCV: Hypothetical Example

Alkaline phosphatase internal QC has an SD of 0.56 U/L at a mean of 40 U/L. \( CV_A = \frac{0.56}{40} \times 100 = 1.4\% \)

Within subject biological variation (\( CV_I \)) is 6.4\%

Formula is: 
\[
RCV = 2^{0.5} \times Z \times (CV_A^2 + CV_I^2)^{0.5}
\]

RCV at 95\% = 1.414 \times 1.96 \times (1.4^2 + 6.4^2)^{0.5} = 18\%
RCV at 99\% = 1.414 \times 2.58 \times (1.4^2 + 6.4^2)^{0.5} = 24\%

Therefore, if the laboratory is mainly interested in identifying large variations in this analyte (\( P < 0.01 \)), a delta check limit of 24\% change in serial results (or higher) could be established, or an absolute difference of 9.6 U/L at 40 U/L levels.
Index of Individuality (II):

- Fluctuation within an individual
  - Within-individual variation ($CV_I$)
  - Between-individual variation ($CV_G$)

\[ II = \frac{CV_I}{CV_G} \]

- Low values (< 0.6):
  - Tightly regulated within an individual
  - Variation may exist between people
Index of Individuality (II):

- Analytes with low II:
  - Maintained within a small interval for each person
    - Only a small portion of the actual reference interval
  - Large change in analyte? Good chance that value is still within the reference interval
    - Thus—reference interval not as helpful to indicate a change in patient status
    - Delta check may be beneficial

Fraser, Biological Variation, AACC Press 2001
Index of Individuality (II):

- **Analytes with high II:**
  - Individual values found anywhere within the reference interval
  - Large change in analyte? Good chance the value will fall outside the reference interval

  - Thus—the reference interval itself indicates a biologically relevant change

---

Fraser, Biological Variation, AACC Press 2001
Institution of the Delta Check: Recent Examples

• Troponin:
  – 20 or (30%) change in baseline values may help delineate acute from chronic causes of elevation, identification of risk
  – Assay-dependent delta check limits
    • Lower imprecision = smaller changes required for significance

• Determining criteria for significant change
  – Monoclonal gammopathy
  – Dehydration
  – Creatinine for AKI detection

Questioning Utility:

• Computer modeling approach: identify mislabeled specimens?

• Two inpatient populations
  – Trauma/critical care center
  – Cancer/transplant population

• Findings:
  – Sodium, potassium = unlikely to identify mislabeling events
  – MCV = best predictor, fewest false-positives
  – Performance varied between patient populations

Multiple tests can reveal multiple things...

- Examination of multiple test results
  - You SHOULD NOT see...
    - Direct bilirubin > total bilirubin
    - Albumin > total protein
    - RBC morphology that doesn’t correlate with measured indices
    - Extreme elevation of only one liver enzyme (AST, ALT)
    - Extremely elevated creatinine with normal BUN

- If *multiple* delta check limits fail, the likelihood of sample misidentification is increased

Delta Checks: Issues and Shortcomings

- Balance error detection with false-positives
  - Cost of investigating rule failures
  - Remember: Majority of failures are due to changes in patient status

- Population in question
  - Inpatient vs. outpatient populations
  - Treatments and therapies (e.g., transfusions, chemotherapy, transplantation)
  - Population may dictate useful analytes (e.g., creatinine for renal patients)

- Many previously established delta check limits were determined in healthy populations
Outline: The Delta Check in Action

Definitions

Causes

Institution

Implications & Investigation Tips
To Report or Not to Report:

There is a fine balance between cancelling questionable results and reporting them:

- **Implications of result cancellation:**
  - Difficult to redraw
  - Neonate issues
  - Loss of blood volume
  - Delayed treatment
  - Delayed discharge

- **Implications of reporting incorrect results:**
  - Lengthened hospital stays, inappropriate medical care, economic, psychological and social issues
  - Implications beyond chemistry and hematology
    - Transfusion Services
    - Immunology
    - Infectious Diseases
    - Genetic and Molecular Testing
  - Harm may not be realized for hours, days or years
General Checklist: Starting the Investigation

1. Repeat analysis
   – Confirm correct patient was analyzed
   – Make new aliquot, if applicable

2. Investigate pre-analytical issues
   – Correct sample type (serum, plasma, whole blood)
   – Gross hemolysis, icterus, lipemia
     • Check for hemolysis of whole blood samples
   – Clots, air bubbles

3. Investigate analytical issues
   – QC, proper reagents, proper calculations
   – Isolated event, or others from same run

All check out?
Consider biological explanations…
General Tips to Confirm Discrepant Results:

- Do lab values match previous results?
  - Look at test history and overall trends
  - Look at > 2 results to confirm trends
- Were the previous results questionable?
- Look at patient location
  - NICU, Labor & Delivery, Oncology, etc.
  - Recent surgery?
- Was a type and screen ordered?
  - Suggests recent transfusion
- Were therapeutic drug monitoring tests ordered?
  - “None Detected” suggests possible misidentification

Think beyond the immediate lab area:
Chemistry, hematology, blood bank, immunology, infectious diseases, molecular genetics, microbiology may ALL be affected.
Sentinel event: Wrap-up

- Multiple delta check failures
- Type and screen OK
- Transfusion reaction

Immunocompromised (HIV+) patient, thus reaction was not lethal.

Method of conveying laboratory alerts is critical.
Summary:

- Delta checks can be useful tools for detecting sample quality issues, sample misidentification and biologically relevant changes in patient status.

- Preanalytical error, analytical error and biological variation are possible causes of discrepant results.

- Delta check limits should be tailored to particular patient populations.

- Multiple sources of error must be considered when determining delta check limits.

- Consequences to patient care must be considered when deciding to cancel or report a discrepant laboratory result.
Additional Resources:

- Fraser, CG. Biological Variation: From Principles to Practice. AACC Press (2001).
- [http://westgard.com/biodatabase1.htm](http://westgard.com/biodatabase1.htm)
Contact Information:

Joely Straseski, PhD, DABCC, FACB
Assistant Professor of Pathology
Medical Director, Endocrinology
Co-Medical Director, Automated Core Laboratory
ARUP Laboratories and University of Utah
joely.a.straseski@aruplab.com