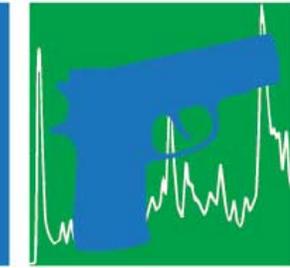


**FORENSIC SCIENCE
ERROR MANAGEMENT**

**INTERNATIONAL
FORENSICS SYMPOSIUM**

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Abstract:

CALCULATING THE TRUE COSTS OF ERRORS IN FORENSIC CASEWORK

Implementation of robust quality management systems, best practices and accreditation have become industry standards leading to the global reduction of errors within the forensic community. More recently, increased awareness of human factors associated with bias in forensic casework will bring further improvements to quality practices. However, none of these changes will ever bring about a zero error environment. Errors will continue to occur and have an enormous impact on the delivery of accurate and timely results, Moreover, their costs and downstream effects may not be known, obvious or immediately calculable. In this presentation we will review some common forensic errors, identify factors contributing to their costs (monetary and otherwise) and review cost containment practices used by various industries in an effort to start a dialog for understanding and calculating the true costs of errors in forensic casework.

Calculating the True Costs of Errors in Forensic Casework

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To Err is Human

Human error is natural. It is the result of the human brain's design and its limitations. We actually need to make mistakes to help us learn.

Although human error is inevitable and normal, it does not mean a mistake has to end in failure.



Near Miss

Events that cannot be classified as substantial errors, but whose occurrence suggests that there is probably a critical point in a working procedure. Monitoring of near misses can be useful in order to prevent these 'almost errors' from occurring again or to prevent them evolving into 'relevant errors.'

Error

Deviation from accuracy or correctness. Holding mistaken opinions or beliefs. A moral offense.

Errors in Perspective 2011 Data

- Total number of Analysis Requests **67,330**
(Includes completed, no work and canceled requests)
- Total number of Quality Assurance Inquiries **31**
- Percentage of detected errors **<0.05%**

We have an obligation to work harder, and smarter to reduce and correct these errors.

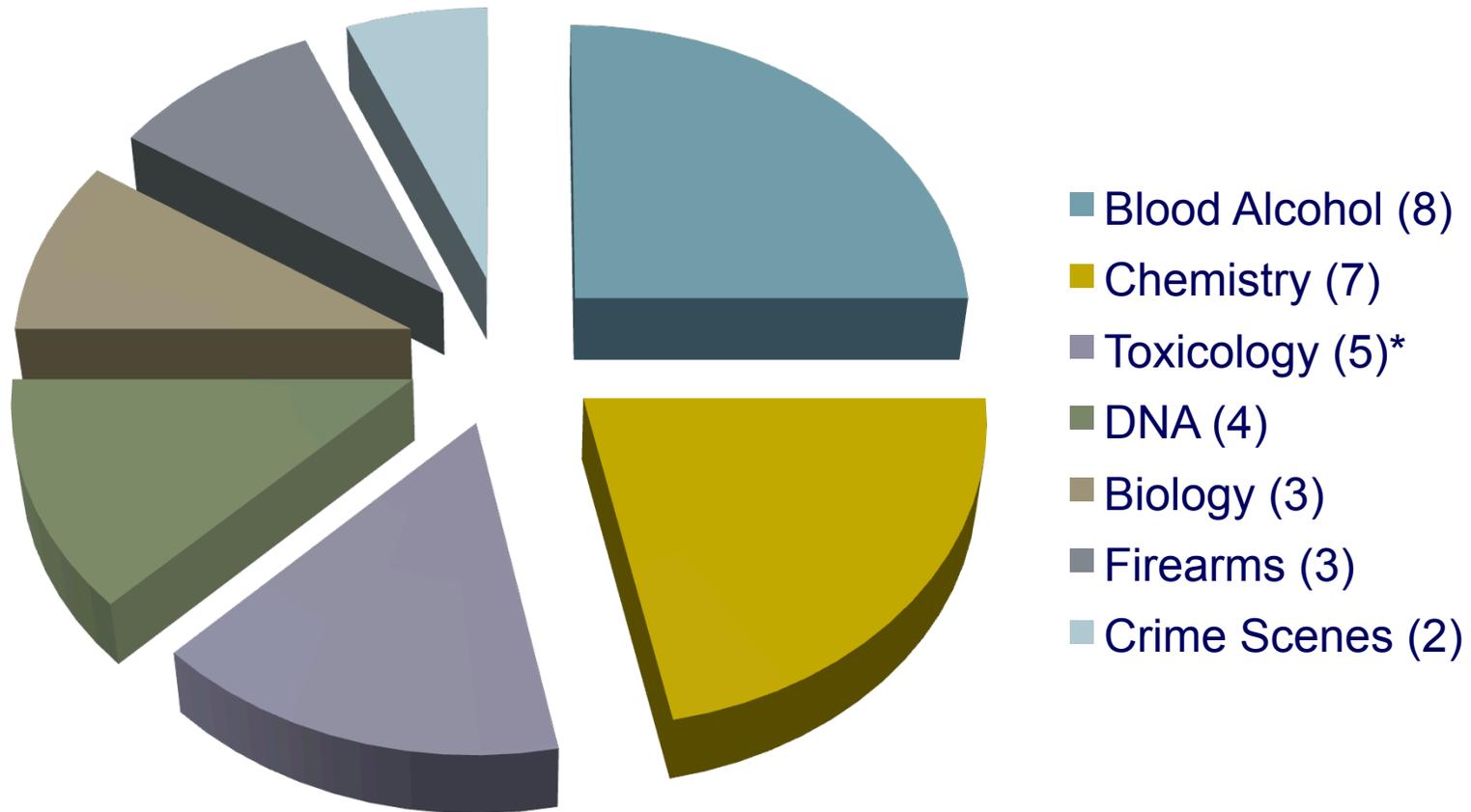
The good news...

This is a very small number.

The bad news...

What if these errors affected you?

Errors by Discipline





High Throughput

- Not surprisingly most errors are seen in the high throughput disciplines

- Blood alcohol
- Drug toxicology
- Chemistry
- DNA

Error Data

- If You Don't Measure it, You Can't (and Don't) Manage it
- We must collect and analyze error data





Laboratory Errors

Root Causes/Causative Factors

- Human factors
- Lack of leadership/management oversight
- Lack of communication
- Inadequate assessment and corrective action
- Failure to implement preventative actions
- Poor Information management
- Physical environment/culture

Laboratory Errors

Spectrum of Effects

**No Effect on
Quality**

**Minimal
Effect on
Quality**

**Delayed or
Incorrect
Results**

**Negative
Effect on
Public Safety**

**Miscarriage
of Justice**

Types of Laboratory Errors

Lack of Knowledge of Quality Management System

- Release of un-reviewed cases notes
- Use of old procedure after new procedure issued
- Unaware of updated procedure

General

- Distraction caused by work interruptions
- Distraction caused by answering phone between samples
- Inadequate QA/QC procedures
- Use of Poor Judgment
- Speed/pressure to get work done

Safety

- Accidental discharge
- Shipment of loaded firearm

Maintenance Procedures

- Incorrect maintenance procedures followed
- Required maintenance not performed

Standards:

- Use of untraceable reference materials
- Reusing standards after failed run

Misanalysis:

- Misinterpretation of data
- Misidentification
- Sloppiness of note taking, documentation led to reporting incorrect results
- Inadequate notes or analysis to support findings
- Recording wrong test results

Types of Laboratory Errors

Evidence Handling

- Evidence labeling error
- Evidence stored improperly
- Failure to inventory evidence properly
- Incorrect or incomplete chain of custody
- Pill or other evidence miscount
- Improper evidence packaging
- Lost Evidence
- Improper sample destruction
- Evidence theft
- Drug trafficking
- Evidence tampering
- Dry-labbing

DNA database and Interpretation Errors

- Missed hit notification
- Missed DNA match
- False inclusion or exclusion
- Incorrect mixture interpretation

Untimely Analysis of Evidence

- Delay in exclusion of suspect
- Delay in identification of suspect
- Evidence no longer suitable for analysis

Management Oversight

- Lack of management action when problems found
- Failure to train management staff

Types of Laboratory Errors

Data Handling and Records

- Accidental or deliberate deletion of test data
- Accidental or deliberate destruction of original records
- Accidental or deliberate omission of test data

Wrong sample analyzed, wrong data (result, name etc.) reported:

- Wrong sample selected
- Sample mix-up or switch at initial aliquot
- Sample mix-up or switch during re-aliquot
- Data mix-up resulting in incorrect report
- Pick wrong item from drop down menus
- Cut and paste errors
- Opening more than one sample at a time results in sample switch

Contamination issues:

- Analyst DNA profile found in casework
- Blood alcohol sample contaminated with internal standard
- Sample carryover
- Cross contamination of open samples in close proximity
- Poor analyst technique in LP leads to DNA profile found in multiple cases
- DNA or other contamination from manufacturer

Pipetting errors:

- Mis-pipetting
- Sample fail from insufficient wiping or cleaning
- Draw up vs dispense errors

Types of Laboratory Errors

Measuring Devices:

- Incorrect physical measurement of bullet land impressions
- Incorrect calculation of bloodstain angle of impact

QC Checks

- Use of expired pipettes
- Use of expired or non QC checked reagent
- Failure to perform required maintenance procedures
- Use of devices out of calibration

Instrument/Software settings

- Failure to verify DNA software is up to date
- Failure to verify BA computer settings are correct
- Incorrect instrument settings

Technical Procedures

- Not following technical procedures
- Use of unapproved procedures
- Deviation from procedure without approval
- Analyst states the procedure is vague
- Wrong procedure followed
- Failure to follow approved procedure
- Use of unvalidated procedure
- Analyst unaware of new procedure

PRC Inquiries/Proficiency issues

- Failed proficiency test
- Failure to use terminology supplied by test provider
- Missed proficiency due dates
- Failure to take and successfully pass a proficiency test

Types of Laboratory Errors

Intermediate check/QC procedures

- **Insufficient review of results**
- Failure to follow QA/QC procedures
- Change in process or instrument not adequately checked before use
- Ignoring failed intermediate check and reporting results
- Stating results of intermediate check or QC check is an acceptable 'deviation from procedure after it has been run
- Not addressing issues found during QC/QA check in a timely manner.
- Allowing use of instrument or equipment while in disrepair

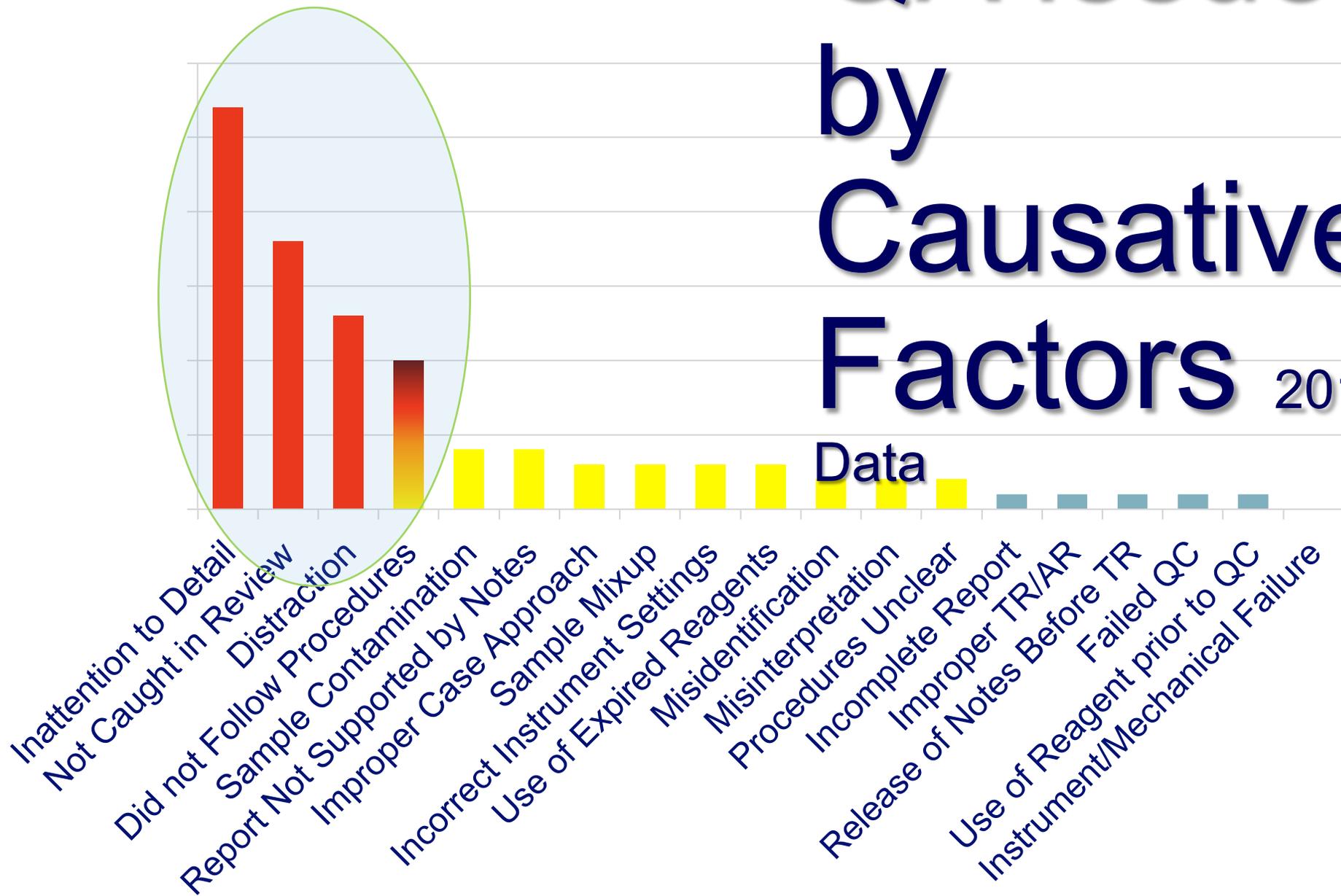
Analyst, Technical Reviewer and Administrative Reviewer reviews:

- **Errors should have been caught prior to case release with better review of data**
- Issues found during monthly QA audits
- Typographical errors in notes or test report

Testimony

- **Poor testimony review**
- Misleading or false testimony
- Failure to qualify as an expert in subject area
- Purporting to be an expert when not qualified in a subject area

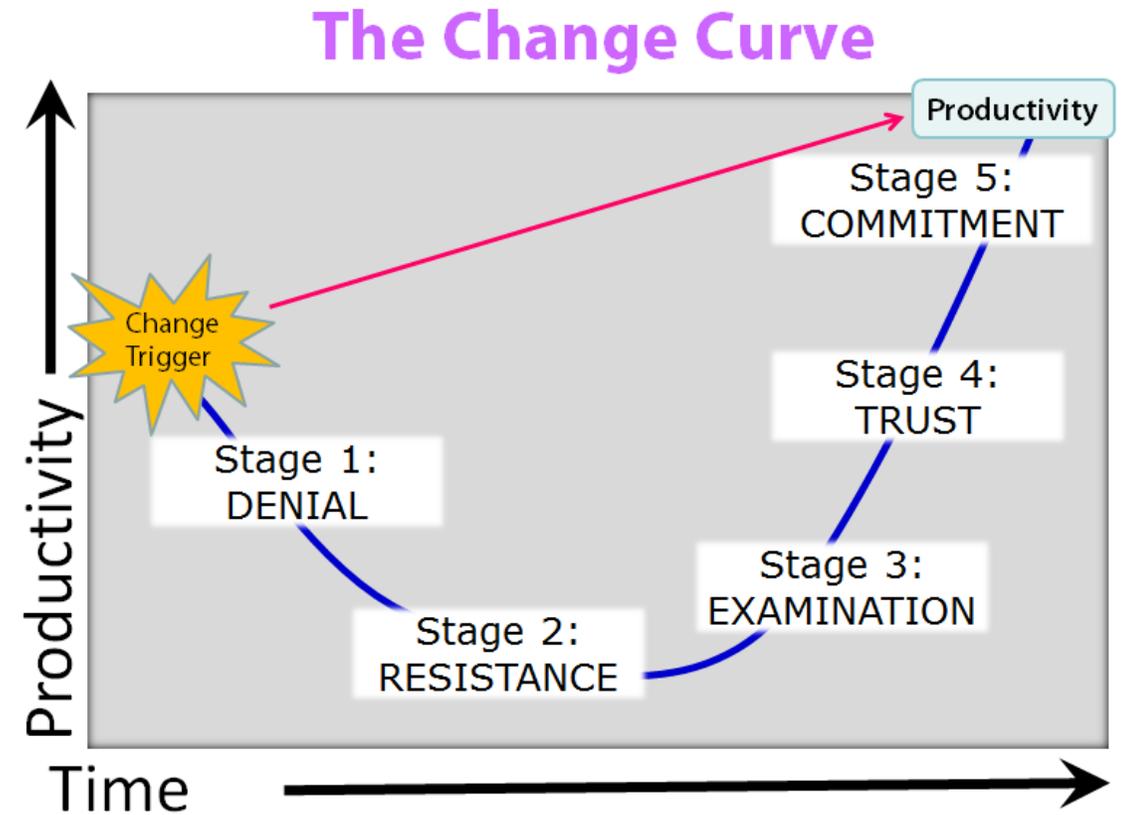
QA Issues by Causative Factors 2011



Righting Wrongs

Our Obligation to Correct and improve

- Discovery of errors can trigger change
- Human beings are naturally resistant to change.
- Change is a process
- Change takes time
- Change can trigger improvement
- Lack of change contributes significantly to cost



“Costs”

The sum of more than just the direct and indirect (Standard) production costs to make a product or deliver a service.



Standard Production Costs

Just the Tip of the Iceberg

Standard Direct Costs:

Costs attributed to the production of specific goods or services. Direct costs include materials, labor and expenses related to the production of a product.

Standard Indirect Costs:

Overhead, depreciation, maintenance, utilities. Personnel costs for management, and support personnel. Non casework related supplies.

**Hidden, less
obvious costs**

Calculating the Cost of Errors

It is What You Don't See Coming that Will Kill

Commonly Measured Failure Costs

Avoidable test failures

Complaints

Reanalysis

Rejected Work

Cancelled Work

Errors

Hidden Failure Costs

Avoidable Labor Costs

Management Costs

Delayed Training

Increased Litigation

Past Due Deliverables: Backlogs

Discovery Requests

Remediation Costs

Retraining Loss of Reputation

Brady Obligation Fatigue

Increased Pressure

Damage Control Lowered Morale

Negative press

Unexpected Costs

Personnel Actions Lost Productivity Can't Recruit Employees

Additional Materials Costs

Public Safety Impact

Accreditation in Jeopardy

Customer Notification

Miscarriage of Justice

Risk Management Costs

Cost of Quality (COQ)

May not be what you expect...

The "cost of quality" isn't the price of creating a quality product or service. It's the cost of NOT creating a quality product or service.

Cost of Poor Quality (COPQ)

AKA Poor Quality Costs (PQC)

Costs that would disappear if systems, processes, and products (and people) were perfect.

Cost of Quality Equation

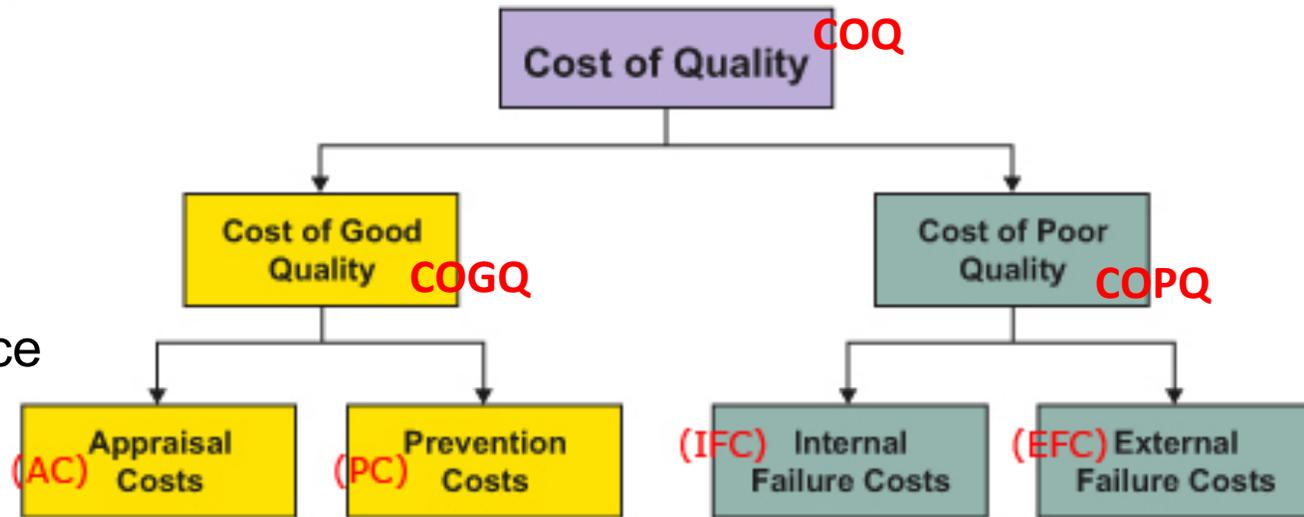
Sum of costs incurred

-Investing in the prevention of nonconformance to requirements. (PC)

-Appraising a product or service for conformance to requirements. (AC)

-Failing to meet requirements. (IFC + EFC)

-Unknown costs (U)



$$\begin{aligned} \text{COQ} &= \text{COGQ} + \text{COPQ} \\ &= (\text{AC}) + (\text{PC}) + (\text{IFC}) + (\text{EFC}) + (\text{U}) \end{aligned}$$

Total Cost of Quality

- Investment in prevention reduces failure costs



Corrective Action Preventative Action (CAPA)

See the potential event and plan to avoid it



Learn from the event and avoid its recurrence

Proactive



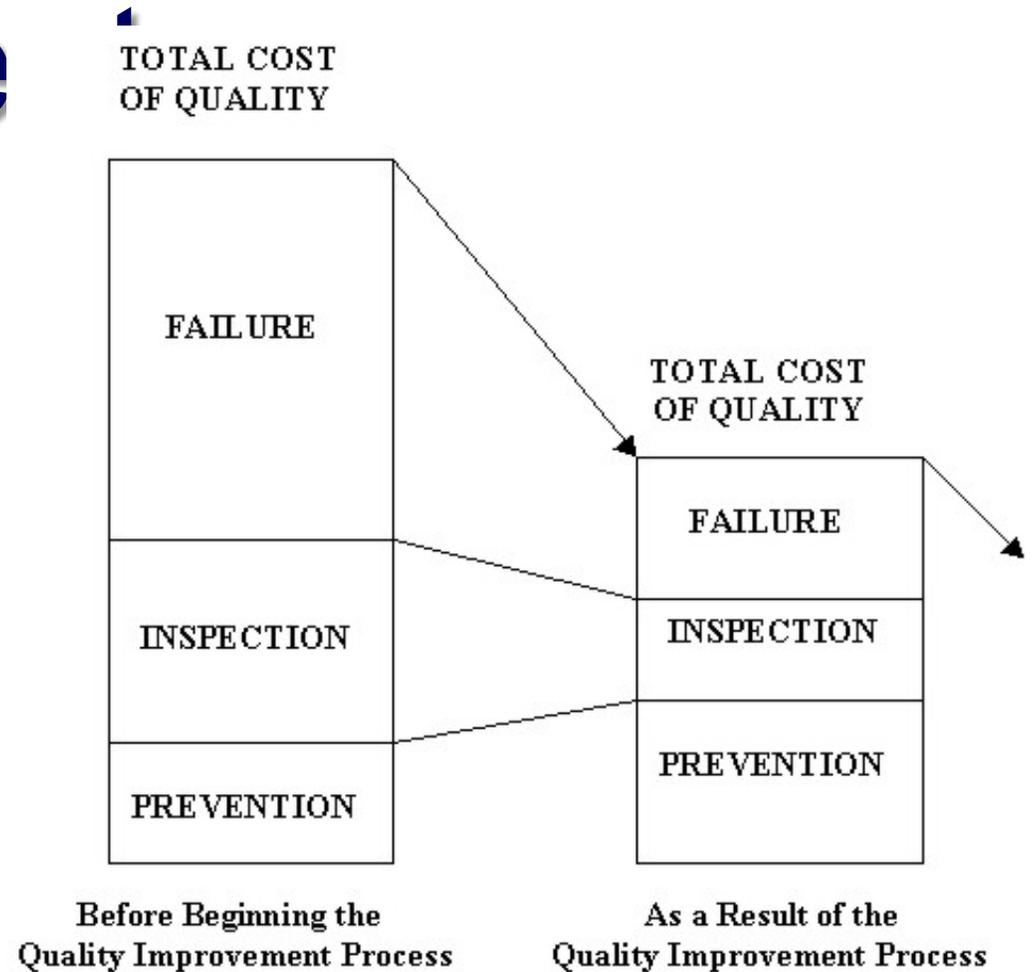
Address the event and its consequences

Reactive



Quality Improve

- Implementation of quality management systems reduces costs.
- Focus on Prevention and Inspection reduces the number and cost of failures.



Early Intervention

An Ounce of Prevention is Worth a Pound of Cure.

Focus on Prevention not Correction

- A preventive action is a process for detecting potential problems or non-conformance's and eliminating them, before they occur.
- The documentation for a preventive action provides evidence that an effective quality system has been implemented that is able to anticipate, identify and eliminate potential problems.

Relative Cost of Errors

- Errors caught and corrected early have less negative impact (cost)
- Every time work is redone, retested, rejected, corrected, or questioned, the cost of quality increases





QC Rechecks

Increased Detection of Errors and Collection of Error Data

- Rework a percentage of each analyst's work each month
- Analysts do not know which cases will be selected
- Identify opportunities for process and performance improvement
- Identify and root out "bad apples"
- Objective evidence for corrective actions/personnel actions
- Easily implemented in drug, and toxicological analysis
- More challenging to implement in other disciplines
- Opportunity to collect error data



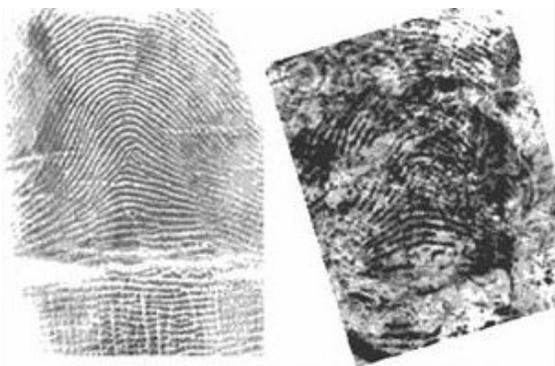
Error Post Mortem

Debriefing and Incident Review is Critical

- Transparent process
- Share details of incidents. No silos.
- Focus on improving processes and systems. Not about blame.
- Work with vendors to improve products
- Work with staff and advisors to improve process
- Did we succeed? What were the actual results?
- What went well and why?
- What didn't go well?
- What was the effect?
- What would we do differently next time?
- Action items
- Collect data

Forensic Science Errors are Not Unique...

We can learn a lot from errors in other industries



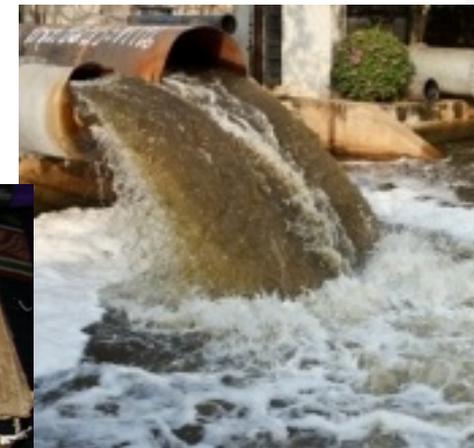
Latent Print
Misidentification



Tool Retention



Damaged Products



Contaminated Water



Commuter Train Crash

Forensic Science Processes are Not Unique

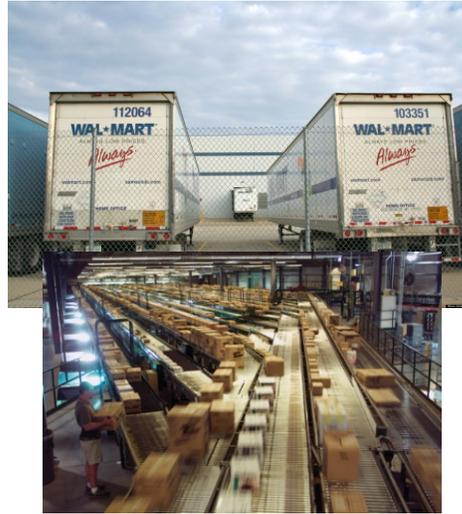
We Can Learn a Lot from Other Industries



High Throughput
Toxicology
Workflow



Fast food:
Delivery of orders with
consistent accuracy
and precision



Retailer:
Exceptional Supply
Chain Management



Automotive
Industry: Total
Quality
Management
(TQM) and robotics



Pharmaceutical Industry:
FDA Good Manufacturing
Practices (GMP)

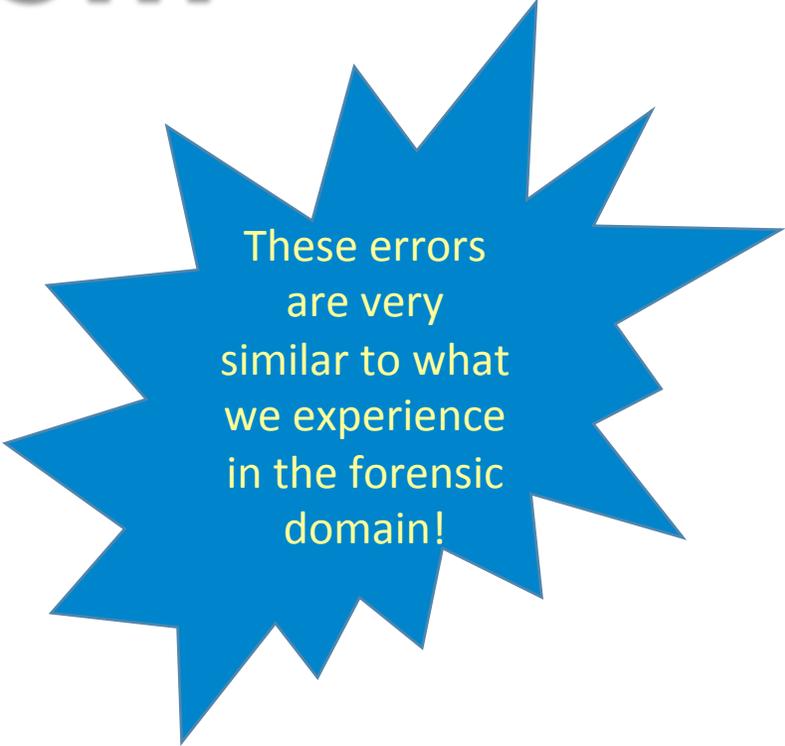
A Comparison of Errors Across Industries

	Medical	Parcel Service	Public Health	Public Safety	Transportation	Forensic Services
Increasing Negative Impact	Patient Death due to medication error	Overloaded cargo plane crashes resulting in loss of life	Contaminated food or water results in consumer death	Unjustified shooting leads to suspect's death	Train crash due to mechanical issue results in loss of life	Untimely analysis delays identification of suspect leading to public safety risk (preventable crime occurs)
	Operation on wrong patient or part results in harm	Delivery of incorrect goods has harmful effect on consumer	Public exposure to raw sewage spill due to aging pipe results in preventable disease outbreak	Incorrect witness ID leads to wrongful incarceration and delay in apprehension	Loss of radar, communication or tracking systems results in traffic diversion, delay and increased crash risk	Incorrect test results due to sample switch leads to wrongful conviction and miscarriage of justice
	Baby abducted from neonatal unit	Loss or misdirection of Package	False negative test result indicating water is safe to drink	Prisoner escape	Tractor trailer refrigeration fails. Spoilage occurs	Loss of evidence
	Defective hip implant placed in patient	Consumer receives damaged goods	Loss or misdirection of radiologic or disease agents	Gun sold in error to prohibited person	Failure to find prohibited item during airport screening	Screening test or procedure fails to identify evidence

What Can we Learn from Other Industries?

2 Examples:

- Medical: Operation on Wrong Body Part or Wrong Patient
- Airlines: Mechanical failure leading to crashes



These errors are very similar to what we experience in the forensic domain!

Medical

Operation on Wrong Body Part or Wrong Patient

1999 Medical Institute Report, “To Err is Human” is analogous to the NAS Report on Forensics.

Goals:

- To increase the accuracy of patient identification using multiple patient identifiers and a ‘time out’ procedure before invasive procedures
- Implement a pre-operative verification process to confirm documents and implement a process to mark the surgical site and involve the patient/family

System Factors-Medical Errors

- Lack of institutional controls/formal system to verify the correct site of surgery
- Lack of a **checklist** to make sure every check was performed
- Reliance solely on the surgeon for determining the correct surgical site
- Unusual **time pressures** (e.g., unplanned emergencies or large volume of procedures)
- **Pressures** to reduce preoperative preparation time
- Procedures requiring **unusual** equipment or patient positioning
- Patient characteristics, such e.g. obesity or unusual anatomy, that requires unusual positioning of the patient
- **Exclusion** of certain surgical team members
- Team **competency** and **credentialing**
- Availability of information
- **Organizational culture**
- Orientation and **training**
- **Staffing**
- Environmental safety/security
- **Continuum** of care

Process Factors-Medical Errors

- **Inadequate** patient **assessment**
- **Inadequate** medical record **review**
- **Miscommunication** among members of the surgical team and the patient
- **More than one** surgeon **involved** in the procedure
- Multiple procedures on multiple parts of a patient performed during a single operation
- **Failure to include** the patient and family or significant others when identifying the correct site
- **Failure to mark** or clearly mark the correct operation site
- **Incomplete or inaccurate communication** among members of the surgical team
- **Noncompliance with procedures**
- **Failure to recheck** patient information before starting the operation

Universal Protocol for Preventing Wrong Site, Wrong Procedure, Wrong Person Surgery™

Prepared by the Joint Commission on Accreditation of Healthcare Organizations, 2003.
Goal: Prevent wrong site, wrong procedure, wrong person surgery.

- Consensus of medical experts
- Endorsed by 40+ professional medical organizations
- A robust approach—using multiple, complementary strategies
- Active involvement and communication among all members of the surgical team
- To the extent possible, the patient (or advocate) should be involved in the process.
- Consistent implementation of a standardized approach using a universal, consensus-based protocol will be most effective.
- Flexible protocol to allow for implementation with, appropriate adaptation, when required to meet specific patient needs.
- A requirement for site marking on procedures involving right/left distinction, multiple structures (fingers, toes), or levels (spine).

Universal Protocol for Preventing Wrong Site, Wrong Procedure, Wrong Person Surgery™

Preoperative verification process

Purpose: To ensure all relevant documents are available prior to the start of the procedure and that they have been reviewed and are consistent with each other and with the patient's expectations and with the team's understanding of the intended patient, procedure, site, and, as applicable, any implants. Missing information or discrepancies must be addressed before starting the procedure.

Process: An ongoing process of information gathering and verification, beginning with the determination to do the procedure, continuing through all settings and interventions involved in the preoperative preparation of the patient, up to and including the "time out" just before the start of the procedure.

Universal Protocol for Preventing Wrong Site, Wrong Procedure, Wrong Person Surgery™

Marking the operative site

Purpose: To identify unambiguously the intended site of incision or insertion.

Process: For procedures involving right/left distinction, multiple structures (such as fingers and toes), or multiple levels (as in spinal procedures), the intended site must be marked such that the mark will be visible after the patient has been prepped and draped.

Universal Protocol for Preventing Wrong Site, Wrong Procedure, Wrong Person Surgery™

"Time out" immediately before starting the procedure

Purpose: To conduct a final verification of the correct patient, procedure, site and, as applicable, implants.

Process: Active communication among all members of the surgical/procedure team, consistently initiated by a designated member of the team, conducted in a "fail-safe" mode, i.e., the procedure is not started until any questions or concerns are resolved.

Airline Industry Maintenance Errors

Japan Airlines Flight 123 –

- Suffered mechanical failures 12 minutes into the flight
- Crashed into Mount Takamagahara, Japan
- A photograph confirmed that the **vertical stabilizer was missing**
- The aircraft was involved in a **prior tail strike which damaged** the aircraft's rear pressure bulkhead.
- The **subsequent repair of the bulkhead did not conform to Boeing's approved repair methods.**
- This reduced the part's resistance to metal fatigue by 70%
- When the bulkhead gave way, the resulting explosive decompression ruptured the lines of all four hydraulic systems. With the aircraft's control surfaces disabled, the aircraft became uncontrollable.

Airline Industry Maintenance Errors

Aeroperú Flight 603 –

- Shortly after takeoff the crew realized that their basic **flight instruments were giving erratic and contradicting readings**
- Despite lack of working instrumentation, **the crew believed they were at a safe altitude**, the pilots declared an emergency and turned to head back to the airport
- However, the pilots **lost track of their location** and altitude and crashed
- instrument failure was caused by a maintenance worker's **failure to remove duct tape** covering the static ports installed during a routine wash necessary to provide correct instrument data to the cockpit.

Airline Industry Maintenance Errors

- **Human factors** are the largest contributor to aircraft accidents.
- aircraft maintenance errors impose a significant **financial burden** on airlines
- are a major cause of flight **delays** and cancellations.
- Poor aircraft maintenance practices are one of the top three causes of aviation accidents
- From 1994 to 2004, maintenance problems have contributed to 42% of fatal airline accidents in the United States (excluding the 9-11 terrorist attacks).
- **Maintenance related accidents and incidents are caused by a breakdown of the organization processes, decisions and culture.**
- Maintenance operations are also affected by human input that shows up as weaknesses in organizational processes leading to
 - - **Lack of motivation**
 - - **Fatigue and stress**
 - - **Time pressures**
 - - **Misperception of hazards**
 - - **Inadequate skills**

How Can Future Airline Maintenance Errors Be Avoided?

- Implementation of Computerized Maintenance Management Software (CMMS)
- Continuous maintenance re-training for aircraft technicians
- Create better mechanisms for reporting, investigating reports, and provide legal protections to the people who informed them
- Provide Human factors training for airline management and aircraft engineers



Learning From Forensic Errors

Case Study No. 1

BACKGROUND

- ‘Experienced’ (25 years) drug analyst with high case throughput
- Technical reviews routinely detect errors (near misses) prior to release
- Analysts bring issues to management’s attention
- Management doesn’t act to correct the problems
- Instituted policy of QC rechecks for a percentage of each analyst's work
- QC recheck reveals drug weight, documentation, identification, pill miscount errors and other issues
- Corrective action process initiated



Learning From Forensic Errors

Case Study No. 1

CORRECTIVE ACTION PROCESS

- Analyst removed from casework
- 25% of casework for the prior 6 months reanalyzed
- Client agencies notified throughout process
- Additional errors found
- Additional casework retested
- Additional errors found
- Analyst remediation unsuccessful
- Analyst resigns



Learning From Forensic Errors

Case Study No. 1

THE COSTS ADD UP...AND CONTINUE

- Significant labor and operational costs to retest/review thousands of cases
- Significant negative impact to laboratory morale
- Drug backlog becomes unmanageable; cases sent to other labs
- Postage and transportation costs incurred
- Significant impact on property control unit
- Level I finding – mandatory reporting to accrediting body
- Extensive client interaction: District Attorneys, Defense Attorneys
- Damage control: press release, *Brady* requests
- Loss of ‘productive’ analyst
- Initial process took more than a year



Learning From Forensic Errors

Case Study No. 2

BACKGROUND

- Laboratory's Quality Assurance Officer performs a monthly review of casework
- Serology cases found that did not conform to the current biology screening procedure
- Bureau Quality Manager/Lab Management determined non-conformity warranted additional follow up
- Corrective action process initiated



Learning From Forensic Errors

Case Study No. 2

CORRECTIVE ACTION PROCESS

- Analyst removed from casework
- Casework review (analyst) found several cases with same issue
- Casework review (bureau wide) determined it was not a systemic problem
- Found biological evidence in two of analyst's cases.
- Biological evidence was subjected to DNA analysis
- DNA profiles were developed and uploaded into CODIS
- Results: 1 case to case hit and 1 convicted felon hit
- Analyst remediation very successful
- Biology technical procedures updated for improved clarity



Learning From Forensic Errors

Case Study No. 2

THE COSTS

- Labor and operational costs to retest/review cases
- Potential negative effect on public safety
- Unclear procedures a possible factor
- Procedures were updated
- Preventative action implemented: Held bureau wide serology conference to review procedures with biology screeners
- Negative effect on laboratory and analyst reputation/credibility

Measure, Manage and Mitigate

A few takeaways...

- We do not work in a zero defect environment
- Measure errors and analyze error data for trends
- Implement a “quality is everyone’s business“ culture
- Emphasize the obligation to correct
- Create a culture of prevention over a culture of correction
- Perform error post mortems
- Understand the myriad inputs to cost calculation
- Share error data
- Transparent process
- Talk to vendors to improve products and processes
- Continuous skills training and retraining
- Human Factors training
- Examine other industries for ideas on error management
- Root Cause and CAPA process training