Patient Safety and Treatment Quality Improvement

Eric Ford, PhD
Johns Hopkins University
Department of Radiation Oncology

Sasa Mutic, PhD
Washington University School of Medicine
Department of Radiation Oncology

AAPM 2011, Vancouver, BC
SAMS session

Disclosures

Ford:
Pilot grant: Elekta Inc.
Chair AAPM Working Group on Prevention of Errors

Mutic:
Grant on patient safety: Varian Medical
Partner: AQUIS, LLC

Estimates for US patients

- 1200 mistreatments per year
- 1 in 600 patients affected

Error spectrum

- Publicized - One side of the spectrum, usually large dosimetric errors – NY Times Articles
- Semi-publicized – RPC data
  - Approximately 30% of participating institutions fail to deliver IMRT dose indicated in their treatment plans to within 7% or 4mm to an anthropomorphic phantom (IJROBP 2008;71(1 Suppl):S71-5)
- Unpublished/unnoted – everyday occurrences
  - “Small” dosimetric errors and geographic misses
  - Suboptimal treatment plans (contouring and dose distributions)
  - Care coordination issues
  - Unnecessary treatment delays
Increasing Complexity of Radiation Treatments

Control Console
circa 1970

Console 2010

Where do errors originate?

- High-risk areas
  - Scattered throughout process
  - Traditional QA does not address these
  - How to find them?


Improving Quality and Safety in Radiotherapy

- Difficult problem
- Often only partial understood
- Methods are available
... I am personally outraged ... – Randy Babbitt, the FAA administrator.

- Babbitt, who suspended the unidentified 20-year veteran, is reviewing the incident.
- The controller told the NTSB it was his fourth straight overnight shift and he was alone in the tower.
- The FAA is looking at overnight staffing issues nationwide. About 30 towers operate with just one controller after midnight.
- Suspected controller errors in 2010 hit 1,887 up from 1,233 the previous year.

- Source: Reuters, March 25, 2011

Research in industrial engineering indicates that for every serious error there are approximately how many near-misses?

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>20%</td>
<td>1. 2</td>
</tr>
<tr>
<td>20%</td>
<td>2. 10</td>
</tr>
<tr>
<td>20%</td>
<td>3. 50</td>
</tr>
<tr>
<td>20%</td>
<td>4. 500</td>
</tr>
<tr>
<td>20%</td>
<td>5. 5000</td>
</tr>
</tbody>
</table>

Heinrich, HW. Industrial accident prevention: a scientific approach, 1st Ed., 1931
Research in industrial engineering indicates that for every serious error there are approximately how many near-misses?

1. 2  
2. 10  
3. 50  
4. **500**  
5. 5000

As a safety improvement measure, the nuclear industry requires on:

- 20% 1. Licensure of operators  
- 20% 2. Board certification  
- 20% 3. In-plant incident reporting system  
- 20% 4. National voluntary reporting system  
- 20% 5. All of the above

As a safety improvement measure, the nuclear industry requires on:

1. Licensure of operators  
2. Board certification  
3. **In-plant incident reporting system**  
4. National voluntary reporting system  
5. All of the above

**Patient Safety and Treatment Quality Improvement**

Sasa Matic, PhD  
Washington University School of Medicine  
Department of Radiation Oncology

AAPM 2011, Vancouver, BC  
SAMS session
Overview
(I) Discovering errors and weak points
   - Matic FMEA
   - Incident reporting

(II) Preventing errors
   - Ford Error-proofing approaches
   - Checklists, portal dosimetry, QC checks
   - Culture of safety

Failure Modes and Effects Analysis

- Objectives:
  - To motivate the use of FMEA and to provide an introduction to the application of FMEA in RT
  - To illustrate the dependence of the results of an FMEA on the approach used and on the individuals performing the analysis
  - FMEA is a tool

Failure Modes and Effects Analysis

- What's the point?
  - Provides a structured way of prioritizing risk.
  - Helps to focus efforts aimed at minimizing adverse outcomes.

- How does FMEA do that?
  - Assembles a group of people (experts) and asks them to dream up potential risks (failure modes) and to assign a few numbers to them.
  - Numbers are easy to sort.

“The purpose of computing is insight, not numbers!” - R.W. Hamming

http://www.webpages.uidaho.edu/~redgeman/Generic%20Presentations/FMEA-&-Measurement_Systems_Analysis.ppt
Failure Modes and Effects Analysis

- It can be used as a standalone tool or as a part of a broader quality system
- FMEA – part of FDA process
- Applications:
  - Equipment/products
  - QA/QC development
  - Process development

Failure Modes and Effects Analysis

- Vocabulary
  - Failure Mode: How a part or process can fail to meet specifications.
  - Cause: A deficiency that results in a failure mode; sources of variation.
  - Effect: Impact on customer if the failure mode is not prevented or corrected.

Failure definition and spectrum

- Publicized - One side of the spectrum, usually large dosimetric errors – NY Times Articles
- Semi-publicized – RPC data
  - Approximately 30% of participating institutions fail to deliver IMRT dose indicated in their treatment plans to within 7% or 4mm to an anthropomorphic phantom (2008.7(2) IJROBP.513
- Unpublicized/unnoted – everyday occurrences
  - “Small” dosimetric errors and geographic misses
  - Suboptimal treatment plans (contouring and dose distributions)
  - Care coordination issues
  - Unnecessary treatment delays

Organizational Goals

- RT - Service or Manufacturing Industry?
  - Quality
  - Patient and employee safety
  - Patient and employee satisfaction
  - Efficiency
Process Itself Matters


• Stable and well defined processes enable:
  – Standardization
  – Quantification
  – Benchmarking
  – Improvements
  – Quality Control

Failure Modes and Effects Analysis

• Identifying potential failure modes
  • Must be comprehensive
  • Must be unambiguous – remove interpretation
  • May be linked to severity

• Identifying potential effect(s) of failure mode
  • Use most severe
  • Easiest one to agree on

FMEA in Numbers

• Occurrence (O) describes the probability that a particular cause for the occurrence of a failure mode occurs. (1-10)

• Severity (S) describes the severity of the effect on the final process outcome resulting from the failure mode if it is not detected or corrected. (1-10)

• Lack of Detectability (D) describes the probability that the failure will not be detected. (1-10)
RPN Score

- Three part system
  - Probability of failure - O
  - Severity of failure - S
  - Probability that a failure would NOT be detected - D

<table>
<thead>
<tr>
<th>Probability of error</th>
<th>Severity</th>
<th>Probability no detection</th>
<th>RPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>A<em>B</em>C</td>
</tr>
</tbody>
</table>

Risk Priority Number (RPN) = Frequency * Severity * Probability

Scoring frequency of failure

- Qualitative Review | Ranking | Failure Rate |
- Failure is unlikely | 1       | < 100 ppm    |
- Few failures       | 3       | < 500 ppm    |
- Occasional failure | 6       | < 0.5 %      |
- Repeated failures  | 8       | < 2.0 %      |
- Failures are inevitable | 10   | > 5.0 %      |

Risk Priority Number (RPN) = Frequency * Severity * Probability

Scoring Severity of Failure

- Severity | Rank |
- Minor to Inconvenience | 1-3 |
- Minor dosimetric error  | 4   |
- Limited toxicity        | 5-6 |
- Serious toxicity        | 7-9 |
- Catastrophic            | 10  |

Six Sigma Levels of Performance

<table>
<thead>
<tr>
<th>Sigma Level</th>
<th>DPMO</th>
<th>Error as %</th>
<th>Quality Yield</th>
<th>Cost of Quality/Cost of Poor Quality as % of Total Operating Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>308,537</td>
<td>30.8%</td>
<td>69.0%</td>
<td>Uncompetitive</td>
</tr>
<tr>
<td>3</td>
<td>66,807</td>
<td>6.7%</td>
<td>93.3%</td>
<td>24-40%</td>
</tr>
<tr>
<td>4</td>
<td>6,219</td>
<td>0.6%</td>
<td>99.4%</td>
<td>15-20%</td>
</tr>
<tr>
<td>5</td>
<td>233</td>
<td>0.0233%</td>
<td>99.98%</td>
<td>5-15%</td>
</tr>
<tr>
<td>6</td>
<td>3.4</td>
<td>0.00034%</td>
<td>99.9997%</td>
<td>World Class</td>
</tr>
</tbody>
</table>
### Probability that a failure will NOT be detected

<table>
<thead>
<tr>
<th>Probability</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/10,000</td>
<td>1</td>
</tr>
<tr>
<td>1/5000</td>
<td>2</td>
</tr>
<tr>
<td>1/2000</td>
<td>3</td>
</tr>
<tr>
<td>1/1000</td>
<td>4</td>
</tr>
<tr>
<td>1/200</td>
<td>6</td>
</tr>
<tr>
<td>1/50</td>
<td>8</td>
</tr>
<tr>
<td>1/20</td>
<td>9</td>
</tr>
<tr>
<td>1/10</td>
<td>10</td>
</tr>
</tbody>
</table>

### Failure Modes and Effects Analysis

- **NO special QA/QC in place for any of the processes or equipment**
- Errors are discovered only downstream through routine processes
- Drastically different from all our training and beliefs
- Challenging to continuously remember

- **Identifying potential cause(s) of failure mode**
  - Depends on experience
  - Often get a wide spread

- **Evaluate current controls or design verification process**
  - Assume no QC
  - This is difficult to do for us

- **Each failure can have multiple causes**
- **Each failure can have multiple consequences**
  - **Example – Isocenter misplacement**
    - **Causes**
      - Laser misalignment
      - Patient setup misinterpretation
      - Many others......
    - **Consequences/Severity**
      - Depend on magnitude of misplacement
      - Use the most severe one
Failure Modes and Effects Analysis

• Two major challenges in completing an FMEA
  1. To be confident that all possible significant failure modes have been identified.
     • This requires that experts contributing to the FMEA have a wide range of experience
  2. The description of the failure mode must be completely clear and different sources that result in the same failure must be differentiated.
     • Different sources may result in the same failure but will have different likelihoods of occurrence.

System Performance

a) The demands on our operations continually change
   – Patient numbers
   – Available staff
   – Available machines
b) Well designed systems maintain constant performance
c) Poorly designed systems cannot cope with these changes

Event Reporting

• Mandatory (statutory)
  – Reporting required by law
  – NRC in U.S.
  – State requirements
  – Mainly concentrated on well defined treatment delivery errors
  – Guidelines for near-miss reporting typically not provided
• Voluntary
  – Mainly at institutional level
  – Some states in the U.S. have voluntary reporting systems – utility for radiation therapy not clear
  – Errors and near misses tracked
Voluntary Reporting
Dependent on Many Factors

• Culture
• Reporting guidelines
• Reporting system
• Competence to interpret reported data
• Willingness to implement, when necessary, significant changes based on collected data and subsequent analyses
• Ability to share the collected data and provide feedback

Lessons Learned I
Naming a Voluntary Reporting System

• We often name our homegrown software by what it does
• Our brand new web-based system, back in 2007, was named “Process Improvement Logs”
  • Our staff provided a nickname

“E-Snitch”

Organizational Culture

• “Shared values (what is important) and beliefs (how things work) that interact with an organization’s structures and control systems to produce behavioural norms (the way we do things around here).”
  • Safety culture
    – Reporting culture
    – Just culture

Organizational Cultures

<table>
<thead>
<tr>
<th></th>
<th>Pathological Culture</th>
<th>Bureaucratic Culture</th>
<th>Generative Culture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do not want to know</td>
<td>May not find out</td>
<td>Actively seek it</td>
<td></td>
</tr>
<tr>
<td>Messengers (whistle blowers) are “shot”</td>
<td>Messengers are listened to if they arrive</td>
<td>Messengers are trained and rewarded</td>
<td></td>
</tr>
<tr>
<td>Responsibility is shirked</td>
<td>Responsibility is compartmentalized</td>
<td>Responsibility is shared</td>
<td></td>
</tr>
<tr>
<td>Failure is punished or concealed</td>
<td>Failures lead to local repairs</td>
<td>Failures lead to far reaching reforms</td>
<td></td>
</tr>
<tr>
<td>New ideas are actively discouraged</td>
<td>New ideas often present problems</td>
<td>New ideas are welcomed</td>
<td></td>
</tr>
</tbody>
</table>

Reason, J., Managing the risks of organizational accidents.
**Reporting Culture**

- Indemnity against disciplinarily proceedings and retribution
- Confidentiality
- To the extent practical, separation of those collecting the event data from those with the authority to impose disciplinary actions
- An efficient method for event submission
- A rapid, intelligent, and broadly available method for feedback to the reporting community

**Just Culture**

Acceptable and Unacceptable Actions

- Vast majority of errors is due to factors and actions where attribution of blame is not appropriate nor useful
- Rare events are due to unacceptable actions:
  - Recklessness
  - Negligent or malevolent behavior
- The line between these can be thin and the tendency is to attribute errors to acceptable actions
- It is operationally impossible to give a blanket immunity which would include unacceptable actions

**Errors and Near Misses**

- Error
  - "The failure of planned action to be completed as intended (i.e., error of execution) or the use of a wrong plan to achieve an aim (i.e., error of planning)."

_Institute of Medicine. To Err is Human: Building a Safer Health System, 2000._

**Errors and Near Misses**

- Near Misses
  - Near Hits
  - Free Lessons
  - Close Calls
  - Near Collisions
Small to Sentinel Events

“We know that single events are rare, but we do not know how small events can become chained together so that they result in a disastrous outcome. In the absence of this understanding, people must wait until some crisis actually occurs before they can diagnose a problem, rather than be in a position to detect a potential problem before it emerges. To anticipate and forestall disasters is to understand regulations in the ways small events can combine to have disproportionally large effects.”

K.E. Weick, “The vulnerable system: an analysis of the Tenerife air disaster” in P.J. Forst et al Reframing Organizational Culture

Error Process

- Errors are product of a chain of causes

What to Report/Track

- Explicit events — frequent events
- Random events
- Actual errors
- Potential errors (near misses)

Reporting process

- Statutory reporting
  - Which agencies should receive reports
  - Which errors are subject to reporting
  - Do near misses have reporting mandates
  - Reporting process
- Voluntary reporting
  - Which errors/near misses to report
  - Reporting process
  - What should be provided in the report
  - Feedback mechanism
AAPM Working Group on Prevention of Errors
Taxonomy Project

**Goal:** Develop a structure to facilitate radiation oncology-specific reporting systems

Team: physicists and physicians + ad-hoc

Five key areas:
- Definitions
- Common process map
- Severity ranking scale
- Root causes taxonomy
- Recommended data structures

Workshop: April 14-15  Final report: July 31

---

**Reporting Systems**

- **Paper**
  - Single form or set of multiple forms
  - Well defined submission and routing process
  - Manual processing and data extraction
- **Electronic**
  - Desktop or web-based applications
  - Commercial and home grown (rad-onc specific)
  - Automatic processing and data mining
  - ROSIS - http://www.clin.radfys.lu.se/default.asp

---

**Paper Based**


**Electronic**

- Web-Based
Electronic Web-Based Notification e-mail, automatically routed through email, alpha pages, text messaging to supervisors

During 19 months - ~500 Events submitted on MD Simulation/Treatment Planning Orders
- ~70% of reported events related directly to the order entry process (MS Word template in MOSAIQ)
  - 28% Incorrect/incomplete simulation instructions
  - 33% Incorrect/incomplete treatment planning orders
  - 6% Scheduling issues
- Solution – Web-based order entry system with business logic and error checking – 20 events during the four months of pilot

The Problem:
- Feedback process often stated as a prerequisite
- Our current implementation does not have a systematic process for direct feedback to individual reporters
- Feedback largely provided to individual groups with major event summaries and process changes
- Large fraction of events submitted unanimously
Conclusions

- Sustainable data collection possible
- Need to collect broader parameters to determine failure triggers
- Electronic processes and standardized classification could facilitate benchmarking among institutions
- Possible savings and improvements could translate to greater resources available for direct patient care

Questions/Comments

Which of the following is not a part of FMEA vocabulary as presented here:

- 1. Failure mode
- 2. Cause
- 3. FTE
- 4. Effect
- 5. RPN

Which of the following is not a part of FMEA vocabulary as presented here:

1. Failure mode
2. Cause
3. **FTE**
4. Effect
5. RPN
Letter “D” in the described FMEA process stands for:

<table>
<thead>
<tr>
<th>20%</th>
<th>1. Demonstrated occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>20%</td>
<td>2. Demonstrated severity</td>
</tr>
<tr>
<td>20%</td>
<td>3. Probability of detection</td>
</tr>
<tr>
<td>20%</td>
<td>4. Probability of no detection</td>
</tr>
<tr>
<td>20%</td>
<td>5. Demonstrated detection</td>
</tr>
</tbody>
</table>

1. Demonstrated occurrence
2. Demonstrated severity
3. Probability of detection
4. **Probability of no detection**
5. Demonstrated detection

Just culture addresses which of the following:

<table>
<thead>
<tr>
<th>20%</th>
<th>1. Indemnity against disciplinary proceedings and retribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>20%</td>
<td>2. Reporting confidentiality</td>
</tr>
<tr>
<td>20%</td>
<td>3. Separation of those collecting the event data from those with the authority to impose disciplinary actions</td>
</tr>
<tr>
<td>20%</td>
<td>4. Justification process for event reporting</td>
</tr>
<tr>
<td>20%</td>
<td>5. A just method for feedback to the reporting community</td>
</tr>
</tbody>
</table>

1. **Indemnity against disciplinary proceedings and retribution**
2. Reporting confidentiality
3. Separation of those collecting the event data from those with the authority to impose disciplinary actions
4. Justification process for event reporting
5. A just method for feedback to the reporting community
Electronic reporting systems can improve all of the following except:

1. Management buy-in
2. Ease of reporting
3. Communication
4. Event analysis and disposition
5. Feedback process

FMEA can be used in radiation therapy for the following:

1. As a part of FDA quality system
2. Treatment machine commissioning
3. New process implementation
4. Design of QA/QM program
5. All of the above
Acknowledgments

• Scott Brame, Ph.D.
• Swetha Oddiraju, M.S.
• Parag Parikh, M.D.
• Merilee Hopkins, CMD
• Lisa Westfall, CMD
• Jonathan Danieley
• Jason LaBrash
• Lakshmi Santanam, Ph.D.
• Peter Dunscombe, Ph.D.

Patient Safety and Treatment Quality Improvement

Eric Ford, PhD
Johns Hopkins University
Department of Radiation Oncology and Molecular Radiation Sciences

Overview

(I) Discovering errors and weak points
   FMEA
   Incident reporting

(II) Preventing errors
   Error-proofing approaches
   Checklists, portal dosimetry, QC checks
   Culture of safety

Error-proofing

How are errors prevented?

• Make them impossible
• Make them less likely
• Make them easier to spot
• Make the impact less
Error-proofing

How are errors prevented?

• Make them impossible ... “forcing functions”
• Make them less likely
• Make them easier to spot
• Make the impact less

Forcing functions to ELIMINATE mistakes

In simulation training residents have tried to defibrillate patients while the lead was still in the dummy load for test – perceptual narrowing

Peter Doyle, PhD, Johns Hopkins, 2011

Forcing functions to ELIMINATE mistakes

Gamma Knife C helmet collimators

... interlock to prevent the use of the wrong helmet

Elektro Inc.

Example Failure Mode:

Plan pulled up for wrong patient in R&V system

Goal: Make the error impossible

Two proposed solutions:

“Time-out” vs. Patient ID card
Example Failure Mode:
Treatment plan and DRR (film) pulled up in R&V system

- Patient ID card scanner
- Pulls up electronic record in R&V system
- Even better solutions? RFID technology

Error-proofing

How are errors prevented?

- Make them impossible
- Make them less likely
- Make them easier to spot
- Make the impact less

Checklists

Checklists

- Standardization of important tasks
- Making sure they get done
Error-proofing Example

- Physician intends to treat R calf but puts beams on L calf
- Cause: patient CT feet-first, no obvious R/L indicator
- Caught during planning by alert dosimetrist
- Incident report logged. Discussed at QC meeting.

Error-proofing Example

Which side is left?

Error-proofing Example

Radiology
Error-proofing Example

Which side is left?

Solution | Challenge
---|---
Train people not to do this | Weak solution. Turnover.
Setup picture R&V | R&V often not open
BB on involved side | Mistake side. Miss or mistake BB.
Wire L ankle | Miss wire. Mistake for scar.
Write an "L" as a contour | RTT mistakes side.
Rewrite software | Vendor response required
L side marker | ??

Error-proofing Example

“L” marker placed on left side of patient
Error-proofing Example

<table>
<thead>
<tr>
<th>Solution</th>
<th>Challenge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Train people not to do this</td>
<td>Weak solution. Turnover.</td>
</tr>
<tr>
<td>Setup picture R&amp;V</td>
<td>R&amp;V often not open</td>
</tr>
<tr>
<td>BB on involved side</td>
<td>Mistake side. Miss or mistake BB.</td>
</tr>
<tr>
<td>Wire L ankle</td>
<td>Miss wire. Mistake for scar.</td>
</tr>
<tr>
<td>Write an “L” as a contour</td>
<td>RTT mistakes side.</td>
</tr>
<tr>
<td>Rewrite software</td>
<td>Vendor response required</td>
</tr>
<tr>
<td>L side marker</td>
<td>Marker on wrong side</td>
</tr>
</tbody>
</table>

Error-proofing

Forcing functions
Make more obvious
Policy and procedure
Staff training

Institutes Safe Medical Practices

How are errors prevented?

- Make them impossible
- Make them less likely
- **Make them easier to spot … QA**
- Make the impact less

Common QA checks

- Double check of every plan by 3 people
- Measurement of dose (in some cases)
- Peer review (Chart rounds)
- Films and CT (daily to weekly)
Wrong isocenter:  
BB premark not set right in treatment planning system

Wrong fields:  
Patient treated with another patient’s plan (both prostate)

Wrong location:  
Wrong GTV-to-PTV expansions

Quantifying Quality Control

An analysis of the effectiveness of common QA checks

- JHU & Wash U
- Data:
  - incident reports: 2007-2011
  - 4,407 reports
  - 292 (7%) “high potential severity”

Ford, Mutic, et al.
Wrong isocenter: BB premark not set right in treatment planning system
Wrong fields: Patient treated with another patient’s plan (both prostate)
Wrong location: Wrong GTV-to-PTV expansions

Quantifying Quality Control
- MD chart review
- Physicist chart review
- Online CT: check by physician
- SSD check
- In vivo diode measurements
- Check list
- Online CT: check by physician
- Pre-treatment IMRT QA

Note: checks are not used in isolation
How effective are COMBINED checks?
Quantifying Quality Control

Most effective checks in combination:
- Physician and physics chart review
- Portal dosimetry or port films
- RTT timeout
- Checklists

Why is this better?

From van Elmpt et al. R&O review, 2008
**Error-proofing**

How are errors prevented?

- Make them impossible
- Make them less likely
- Make them easier to spot
- Make the impact less

"**Culture of Safety**"

A term first used in a report on the Cernobyl disaster (1986)

---

**Culture of Safety**

**Significant reported indicators**

- Event reporting and organizational learning
- Handoffs
- Staffing
- Teamwork – within units, across units

*Mardon et al., J Patient Safety 2010*
Culture of Safety

How to promote culture of safety
• Clear messages and leadership statements
  - event reporting
• Improve handoffs
• M&M conference
• Partner with clinicians

Conclusion
• Promote culture of safety
• Value of incident learning and risk assessment
• Error proofing
  - Standardization
  - Move beyond “QA checks”
  - Evolve toward automated systems

Of the following the most effective method for reducing errors is:

1. Staff Training: 20%
2. Forcing function: 20%
3. QA checks: 20%
4. Policies and Procedures: 20%
5. Punitive actions: 20%

Of the following the most effective method for reducing errors is:

1. Staff Training
2. **Forcing function**
3. QA checks
4. Policies and Procedures
5. Punitive actions
### EPID-based portal dosimetry is:

- **20%** 1. A possible replacement for IMRT QA
- **20%** 2. More sensitive to most common errors than IMRT QA
- **20%** 3. A possible replacement for in vivo diode measurements
- **20%** 4. In development for 20 years
- **20%** 5. All of the above

### A good culture of safety is:

- **20%** 1. Improved by disciplinary measures
- **20%** 2. Enhanced by getting patients treated as quickly as possible
- **20%** 3. Linked to fewer adverse events
- **20%** 4. Mainly the responsibility of management
- **20%** 5. Mainly dependent on having proper QA/QC measures
Acknowledgements

Stephanie Terezakis, MD
Lee Myers, PhD
Ruth Bell, RTT
Ted DeWeese, MD
Annette Souranis, RTT
Danny Song, MD
Richard Zellers, MD
John Wong, PhD

Quality Safety Research Group
Johns Hopkins

Peter Pronovost, MD, PhD
Jill Marsteller, PhD
Ayse Gurses, PhD
Lilly Engineer, MD
Bruce Vanderer, MD

eric.ford@jhu.edu