TG275 AND BEYOND: PLAN CHECKS IN THE MODERN AGE

STEPHANIE A. PARKER, MS, DABR
NOVANT HEALTH GREATER WINSTON-SALEM MARKET, NORTH CAROLINA

CONFLICTS OF INTEREST

• None
DISCLOSURES AND ACKNOWLEDGEMENTS

• Member of TG275
• Some Material and Slides Provided by Other TG275 Members
  • Eric Ford
  • Anne Greener
  • Luis Fong de los Santos
  • Perry Johnson
  • Debbie Schofield

OBJECTIVES

• To discuss the current state of physics plan and chart checks
• To show how physics plan and chart checks relate to error management
• To demonstrate the use of TG-100 Methodology to assess physics plan and chart check processes
• To share TG-275’s experience to date
• To initiate discussion on the role of physics plan and chart checks in quality management and systems thinking
OUTLINE

• Justification and Need
• Background and Team
• Charge and Scope of TG-275
• Error Management
• TG-275 Initial Tasks
• Current Guidelines

• Survey of Current Practices
• TG-275 Risk Assessment (FMEA)
• Survey/FMEA Crosswalk
• Work in Progress
• Summary of TG275
• Systems View/Quality Management

JUSTIFICATION AND NEED

Patient safety improvements in radiation treatment through 5 years of incident learning
Brenda G. Clark PhD †*, Robert J. Brown RTT ‡, Jodi Plaquin MS ‡, Peter Dunscombe PhD †

Practical Radiation Oncology (2013) 3, 157–163

2013
JUSTIFICATION AND NEED

Targeting safety improvements through identification of incident origination and detection in a near-miss incident learning system

Anney Nave, Matthew J. Nyffe, Ralph P. Emrman, Louise E. Jordan, Patricia A. Sternecker, Debra A. Kane, Eric C. Ford, and Jinzheng Zeng
Department of Radiation Oncology, University of Washington Medical Center, 1515 NE Pacific Street, Campus Box 394402, Seattle, Washington 98195

Error Origination

Error Detection

JUSTIFICATION AND NEED

QUARTERLY REPORT
PATIENT SAFETY WORK PRODUCT
Q3 2016

METRIC
Reported Events
Therapeutic Radiation Incidents
Near Misses
Operational/Process Improvement

AGGREGATE CURRENT QUARTER
274
21
27

AGGREGATE HISTORICAL SUM
2345
773
61

Most Commonly Identified Workflow Step Where Event Occurred
Treatment Planning: 30% (83/274)

Most Commonly Identified Workflow Step Where Event was Discovered
Treatment Delivery Including Imaging (e.g., at the machine): 28% (77/274)
Pre-treatment QA Review (e.g., Physics Plan Check): 25% (58/2345)

Medical Physics, Vol. 43, No. 9, September 2016
JUSTIFICATION AND NEED

<table>
<thead>
<tr>
<th>METRIC</th>
<th>AGGREGATE CURRENT QUARTER</th>
<th>AGGREGATE HISTORICAL SUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reported Events</td>
<td>274</td>
<td>2345</td>
</tr>
<tr>
<td>Therapeutic Radiation Incidents</td>
<td>58</td>
<td>645</td>
</tr>
<tr>
<td>Other Safety Incidents</td>
<td>21</td>
<td>171</td>
</tr>
<tr>
<td>Near Miss</td>
<td>79</td>
<td>773</td>
</tr>
<tr>
<td>Unsafe Conditions</td>
<td>89</td>
<td>695</td>
</tr>
<tr>
<td>Operational/Process Improvement</td>
<td>27</td>
<td>61</td>
</tr>
<tr>
<td>Most Commonly identified Workflow Step Where Event Occurred</td>
<td>Treatment Planning: 30% (83/274)</td>
<td>Treatment Planning: 28% (662/2345)</td>
</tr>
<tr>
<td>Most Commonly identified Workflow Step Where Event was Discovered</td>
<td>Treatment Delivery Including Imaging (e.g. at the machine): 28% (77/274)</td>
<td>Pre-treatment QA Review (e.g. Physics Plan Check): 25% (580/2345)</td>
</tr>
</tbody>
</table>

JUSTIFICATION AND NEED

Quality Control Quantification (QCC): A Tool to Measure the Value of Quality Control Checks in Radiation Oncology
Eric Ford, Ph.D.; Stefania Tereaklis, M.D.; Annette Sourenko, M.D.; and Sasa Nucic, Ph.D.
Volume 84 • Number 3 • 2012

![Graph showing effectiveness of quality control checks](image)

Fig. 2. Effectiveness of each individual quality control (QC) check for detecting the reported high severity incidents.
JUSTIFICATION AND NEED

The effectiveness of pretreatment physics plan review for detecting errors in radiation therapy

Olga Gopan, Jing Zeng, Avrey Novak, Matthew Nyflot, and Eric Ford
Department of Radiation Oncology, University of Washington Medical Center, 1959 NE Pacific Street, Box 356045, Seattle, Washington 98195

2016

• Based on Incidents from Departmental ILS
  • Sensitivity of 38% for physics plan review
  • Indicates the need to improve review performance

JUSTIFICATION AND NEED

• Majority of errors occur in treatment planning process
• Room for improvement in physics plan check processes
INTRODUCTION

• TG-275: Strategies for Effective Physics Plan and Chart Review in Radiation Therapy

• April 2015
  • Approval by Therapy Physics Committee & Science Council
  • Assigned TG Number

THE TEAM – TG275 MEMBERS

• Eric Ford, Chair
  • University of Washington

• Lei Dong
  • Scripps Proton Therapy Center

• Luis Fong de los Santos
  • Mayo Clinic

• Anne Greener
  • East Orange VA

• Jennifer Johnson
  • UT MD Anderson Cancer Center

• Perry Johnson
  • University of Miami

• Grace Gwe-Ya Kim
  • University of California, San Diego

• James Mechalakos
  • Memorial Sloan-Kettering Cancer Center

• Brian Napolitano
  • AAMC Representative, MGH

• Stephanie Parker
  • Novant Health, Winston-Salem, NC

• Deborah Schofield
  • Saint Vincent Hospital

• Koren Smith
  • Mary Bird Perkins Cancer Center

• Michelle Wells
  • Piedmont Hospital, Atlanta, Ga

• Ellen Yorke
  • Memorial Sloan-Kettering Cancer Center
CHARGE OF TG-275

- To review existing data and recommendations
- Survey information on current practices
- Provide risk-based recommendations
- Provide recommendations to software vendors

SCOPE OF TG-275

- Types of Procedures
  - External Beam
  - Photon and Electron
  - Brachytherapy
  - Proton
- Types of Checks
  - Initial Plan/Chart Checks
  - Continuing (Weekly) Physics Checks
  - End of Treatment Checks (EOT’s)
CREW RESOURCE MANAGEMENT

CREW RESOURCE MANAGEMENT (CRM)

• Introduced in 1979 – Air Safety
• Set of Training Procedures
• Used in Environments where Human Error can have devastating effects
• Evolved over time - Several “Generations”
• Has been adapted to other fields
  • Including Healthcare

5TH GENERATION CREW RESOURCE MANAGEMENT

- ~ 1990 by Robert Helmreich
- Influenced by work of James Reason
- Focused on Error Management
- Underlying Premise that Human Error is:
  - Ubiquitous
  - Inevitable
  - Valuable source of information
- Set of Error Countermeasures
  - Three lines of defense
  - “Error Troika”

ERROR TROIKA

Mitigate Errors

Trap Errors

Avoid Errors

Eliminate or Lesson the Consequences of Errors

Trap Incipient Errors Before They Become Consequential

REDUCE THE OPPORTUNITY FOR ERROR

TG275 INITIAL TASKS

• Literature Search
• Survey of Current Practices
• Risk Assessment Study for External Beam RT

TG Members Divided into Three Groups to Focus on Specific Tasks
TG-275 will apply TG-100 Methodology to Provide an Update to TG-40 Part VI Sections B & C

TG275 INITIAL TASKS

• Literature Search
• Survey of Current Practices
• Risk Assessment Study for External Beam RT
SURVEY OF CURRENT PRACTICES

• 55 Demographics Questions:
  • 18 -> General
  • 20 -> Initial Plan Check
  • 17 -> On-Treatment Chart Check

• 256 Items Check or Review:
  • 151 -> Initial Plan Check
  • 38  -> Proton Specific Initial Plan Check
  • 52  -> On-Treatment Chart Check
  • 15  -> End-of-Treatment Chart Check

Items Checked during Initial Plan Check Process
Sorted By Level of Agreement
N = 151

90% or better agreement in 25% of the items checked
75% or better agreement in 50% of the items checked

High Level Agreement Items Checked
Low Level
TG275 INITIAL TASKS

• Literature Search
• Survey of Current Practices
• Risk Assessment Study for External Beam RT

FMEA – FAILURE MODES AND EFFECTS ANALYSIS

Map the process and identify major steps.

Identify failure modes for each step.

Identify cause(s) and effect(s) of failure mode.

Score FM’s with respect to Severity (S), Occurrence (O), and (Un)Detectability (D)

Multiply S x O x D to determine RPN (Risk Priority Number)

Sort FM’s based on RPN and Severity
WORKFLOW FOR TG275 RISK ASSESSMENT STUDY

1. Develop Online FMEA Tool on AAPM Website
2. Create Process Map
3. Create Database of Failure Modes
4. Enter Failure Modes and Causes into Online Tool
5. Score FM’s using Abbreviated Scale
6. Analyze Results of 3 Point Scale FMEA

7. Remove Low Scoring FM’s & Combine Causes for Remaining FM’s
8. Score FM’s using Standard 10 Point Scale
9. Analyze Results of 10 Point Scale FMEA
10. Correlate FM’s with Survey Results
11. Develop Recommendations
1. ONLINE FMEA TOOL ON AAPM WEBSITE

- Web Based Online Tool
- Eric Ford and AAPM IT Staff Developed
- Goal: Available for all AAPM Members

2. HIGH LEVEL PROCESS MAP

- Patient Assessment
- Simulation
- Treatment Planning
- Pre-Tx Review and Verification
- Treatment Delivery
- On-Treatment Quality Management
- Post-Treatment Completion
3. CREATE DATABASE OF FAILURE MODES

• Experience of TG-275 Members
  • Individual Lists Generated by Each TG Member

• SAFRON
  • 51 Events identified
  • 38 FM/Cause Combinations Added to Database

3. CREATE DATABASE OF FAILURE MODES

• Validation of Database Against RO-ILS
  • 113 Events Related to Physics Checks Identified by Eric Ford
  • List Compared to Database Generated by Task Group
    • Excellent agreement
    • 97 of 113 events already included in database
    • 10 new causes added to database
    • 2 new failure modes added to the database
3. CREATE DATABASE OF FAILURE MODES

- Final Database
  - 192 Failure Modes
  - Causes for each FM ranged from 1 to 21
  - Total of 594 FM/Cause Combinations

4. ENTER FAILURE MODES AND CAUSES INTO ONLINE TOOL
4. ENTER FAILURE MODES AND CAUSES INTO ONLINE TOOL

5. INITIAL SCORING USING ABBREVIATED SCALE
5. INITIAL SCORING USING ABBREVIATED SCALE

- Scoring Instructions
  - Enter scores based on experience at your institution
  - **Detectability score:**
    - Score this with the view of what is detectable PRIOR to the initial physics plan and chart review.
  - **Severity score:**
    - Score as if the failure goes all the way through to the patient.
    - Score for the most reasonably likely scenario
      - not the worst-case scenario
      - can almost always imagine a scenario where a failure mode propagates in a certain way as to become a severity of 10

- Individuals Entered Scores on the AAPM Website
- Scoring Open April 15 to May 9 2016
- Time Consuming Even With 3 Point Scale
  - ~ 3.5 hours
  - ~2.8 FM/min
5. INITIAL SCORING USING ABBREVIATED SCALE

<table>
<thead>
<tr>
<th>FM Order</th>
<th>95</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure Mode</td>
<td>CT dataset Loaded from a different patient</td>
</tr>
<tr>
<td>Cause</td>
<td>incorrect scan sent from sim (scan completed with incorrect patient name and information)</td>
</tr>
<tr>
<td>Process Step</td>
<td>Treatment Planning</td>
</tr>
<tr>
<td>Comment</td>
<td>[ Add ]</td>
</tr>
<tr>
<td>Severity</td>
<td>3 very severe (hospitalization, death, high chance of recurrence)</td>
</tr>
<tr>
<td>Occurrence</td>
<td>Rate for 500 pts/year</td>
</tr>
<tr>
<td></td>
<td>1 very rare. almost never seen.</td>
</tr>
<tr>
<td>Detectability</td>
<td>Probability of detecting</td>
</tr>
<tr>
<td></td>
<td>2 sometimes occurs</td>
</tr>
</tbody>
</table>

6. ANALYSIS OF 3 POINT SCALE FMEA

- RPN Scores: 1 to 13.94
- Severity Scores: 1 to 3
5. INITIAL SCORING USING ABBREVIATED SCALE

FM Order: 104
Failure Mode: Unintentional re-treatment of a previously treated area
Cause: MD aware of prior reats but did not communicate
Process Step: Treatment Planning
Comment: [Add]

Individual Score

<table>
<thead>
<tr>
<th>IndID</th>
<th>Name</th>
<th>Severity</th>
<th>Occurrence</th>
<th>Detectability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Consensus Final Score

<table>
<thead>
<tr>
<th>Severity</th>
<th>Occurrence</th>
<th>Detectability</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>1.36</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2.64</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Highest Ranking
Severity
S = 3

Highest Ranking
FM
RPN = 13.94
6. ANALYSIS OF 3 POINT SCALE FMEA

7. REMOVE LOW SCORING FM’S

• Needed to Determine Threshold for Elimination of Low Scores
• Kept FM’s with $\text{RPN} \geq 5.5$ and $S \geq 2$
• Eliminated $\sim 40\%$ of the scores
7. REMOVE LOW SCORING FM’S

RPN Values $\geq 5.5$
7. REMOVE LOW SCORING FM’S

- **RPN Values ≥ 5.5**
- **S ≥ 2**

Eliminated 258 FM’s
7. REMOVE LOW SCORING FM’S

- Started with 594 Failure Mode/ Cause Combinations
- Eliminated 258 that Fell Below the Threshold
- 336 Remaining - Still too many
- Combined Causes for Many FM’s
- Final Result for 10 Point Scale Scoring
  - 118 FM/Cause Combinations

8. SCORE FM’S USING STANDARD 10 POINT SCALE

- Scoring Open June 27- July 11, 2016
- 1 to 1.5 Hours to Complete Scoring
- ~1.3 FM/min

Total Time Scoring = 5 hours
If Only Used 10 Point Scale: ~ 7.5 hours
3 Point Scale Scoring Seems to Have Saved about 2.5 Hours
9. ANALYSIS OF 10 POINT SCALE FMEA

• RPN Scores: 30 to 261.33
• Severity Scores: 2.62 to 8.23
9. ANALYSIS OF 10 POINT SCALE FMEA

<table>
<thead>
<tr>
<th>Failure Mode</th>
<th>Cause</th>
<th>Process Step</th>
<th>R</th>
<th>S</th>
<th>O</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very (dangerously) wrong preliminary prescription</td>
<td>Patient Assessment</td>
<td>MD confused or misinformed</td>
<td>122.54</td>
<td>8.23</td>
<td>2.62</td>
<td>5.69</td>
</tr>
<tr>
<td>Unintentional re-irradiation of a previously treated area</td>
<td>Treatment Planning</td>
<td>Communication/Workflow Issue: Patient did not or unable to disclose, MD did not request info, MD did not communicate prior tx info, Dosimetrist aware but did not take into account</td>
<td>158.33</td>
<td>7.92</td>
<td>3</td>
<td>6.67</td>
</tr>
</tbody>
</table>

9. ANALYZE RESULTS OF 10 POINT SCALE FMEA

[Scatter plot showing data points on a grid with labeled axes: S for severity, RPN for risk priority number.]
10. CORRELATE FM’S WITH SURVEY RESULTS

• FMEA/ Survey “Crosswalk”

• 112 High Priority Failure Modes from FMEA
• 153 Checks from the Survey
10. CORRELATE FM’S WITH SURVEY RESULTS

• Identified Failure Modes Potentially Found by Each Check
• Many Checks Could Address Multiple FM’s
  • Ranged from 0 – 12
  • Average of 2.9 FM per Check
  • Identified Highest RPN FM per Check
• Graphed Highest RPN per Check vs. % Use of Check
10. CORRELATE FM’S WITH SURVEY RESULTS

- Examples of High RPN FM’s with High % Use of Checks
  - Special Considerations for radiotherapy (e.g. pacemakers, ICDs, pumps, etc.)
  - Previous radiotherapy treatments
- Description of target location on physician planning directive (e.g. RUL Lung, H&N, L1-L4)
10. CORRELATE FM’S WITH SURVEY RESULTS

• Examples of High RPN FM’s with Low % Use of Checks
  • Final plan and prescription approval by physician
  • Image Guidance Imaging Technique
  • Prescription vs consult note

11. DEVELOP RECOMMENDATIONS

• Recommended Checks
• Recommend Items for Others to Check
• List of Items with Potential for Automation

Emphasis on Adaption Vs. Adoption
• TG275 Report will not be Prescriptive
11. DEVELOP RECOMMENDATIONS

Not a “One Size Fits All” Scenario

IN PROGRESS

• Weekly and EOT Chart Check FMEA
• Brachytherapy FMEA
• Proton Therapy FMEA
TG275 SUMMARY

• TG-275 has completed the External Beam Initial Physics Plan/Chart Check FMEA & Survey Crosswalk
• Currently Developing Recommendations
• Will Repeat the Same Process for Weekly/EOT, Proton, and Brachytherapy

WHERE DO WE GO FROM HERE?

• Lessons from Manufacturing Quality Management
• Lessons from Systems Thinking
• Understand Role of Physics Plan Checks in Overall Treatment Planning Process
TREATMENT PLANNING AS MANUFACTURING PROCESS

Inputs ➔ Process ➔ Output ➔ Inspection ➔ Customer

Imaging Dataset ➔ Treatment Planning ➔ Treatment Plan ➔ Physics Plan Check ➔ Patients

MANUFACTURING QUALITY MANAGEMENT

- Start in Early 1900’s
  - Scientific Management
  - Separated Planning from Execution
  - Focus on Efficiency
  - Quality in Hands of Inspectors
    - Employed hundreds of inspectors
  - Dramatically Increased Productivity
  - Eroded Quality – Excess Scrap
  - Failed to Exploit Most Valuable Resource
    - Knowledge and Creativity of Workforce

Frederick W. Taylor
MANUFACTURING QUALITY MANAGEMENT

• 1950’s - Post WWII Japan
• 1980 - Became known in US
• Deming’s 14 Points
  • Point 3: Understand Inspection
    • Does not add value
    • Rework expensive
    • Encourages Defects by Passing the Buck
• Quality should be in the hand of the workers

W. Edwards Deming


MANUFACTURING QUALITY MANAGEMENT

• 1960’s – Japanese Industrial Engineer
• Zero Quality Control (ZQC)
  • Stop Errors at or Very Close to Source
• Simple & Inexpensive Processes
  • Successive Checking
    • Checking prior work before continuing
  • Self Checking
    • Operators assess own work

Shigeo Shingo

http://www.shingoprize.org/about
MANUFACTURING QUALITY MANAGEMENT

• Poka-Yoke (POH-kah YOH-kay)
  • Simple tools to mistake proof processes
  • Uses Automatic Devices or Methods
  • Prediction or Detection

Prevention Example

Detection Example

QUALITY COST CLASSIFICATION

Prevention Costs
- Doing it Right the First Time
  - Quality Planning
  - Process Control
  - Information Systems
  - Training

Appraisal Costs
- Checking that it was Done Right
  - Inspection
  - Process Measurement

Internal Failure Costs
- Errors that are Caught During Appraisal
  - Scrap and Rework
  - Corrective Action

External Failure Costs
- Errors that Reach the Customer
  - Customer Dissatisfaction
  - Administrative
  - Liability

Minimal Improvement in Overall Quality
- Typical Response: Increase Inspection

Very Expensive: 60-90% of Total Quality Costs
- Increases Appraisal Costs

Helps Guide & Improve our Prevention Processes
- Helps Guide & Improve our Appraisal Processes

High Cost to Both Patients and Staff; but Valuable Source of Information
CURRENT QUALITY MANAGEMENT PERSPECTIVE

- Inspection in Manufacturing
  - Judge quality of manufacturing
  - Discover and help to resolve production problems
  - Ensure that no defective items reach the customer

- Physics Plan Review
  - Assess overall quality
  - Identify and guide improvement opportunities in the planning process
  - Ensure that no errors reach our patients

QUALITY MANAGEMENT IN RADIATION ONCOLOGY

“Benefit to more upstream error proofing of products and processes”
QUALITY MANAGEMENT IN RADIATION ONCOLOGY

• Hierarchy of Effectiveness
  • Reliance on policies and training
    • Usual but least effective approach
  • Best to “hardwire” the systems for success
    • Simplification
    • Standardization
    • Automation
    • Forced Functions

2012

QUALITY MANAGEMENT IN RADIATION ONCOLOGY

• Standardization
• Automation
• Safety Barriers Placement Optimization
• Risk Assessment Approaches
STANDARDIZATION

• Reduces Variation and Random Error
• Pre-requisite to Automation

Standardizing dose prescriptions: An ASTRO white paper
Suzanne B. Evans MD, MPH †, Benedick A. Fraass PhD †, Paula Berner CMD, FAAMD ‡, Kevin S. Collins PhD, RT(R)(T), CMD ‡, Teamour Nurushev PhD ‡, Michael J. O'Neill MD ‡, Jing Zeng MD ‡, Lawrence B. Marks MD ‡
AUTOMATION

• Driven by a need to increase efficiency
• Shortage of medical physicists entering the field
• Some items simply better to check using automated methods

AUTOMATION

• Poke-Yokes in Treatment Planning
  • Scripting
    • Standard ROI’s based on treatment site
    • Standard Beam Arrangements
  • Forcing Functions
    • Display warning if importing images from incorrect patient
    • Display warning if adding a beam with different isocenter
  • Can you think of other current or potential Poke-Yokes?
AUTOMATION

• Need to pay attention to location of automated safety barriers
  • Design safety into the process
  • Put barrier within or immediately following error prone process step
  • Put safety into the hands of the planner
  • Reduce “scrap” or re-work

RISK ASSESSMENT – TG100

• Process Map
  • Need to understand the process
  • Incorporate EVERYONE involved in the process
• FMEA
  • Identify and Rank Failure Modes for Each Process Step
• Fault Tree Analysis
  • Links Process Map and Failure Modes
• Guides Optimal Placement of Safety Barriers
ERROR TROIKA

- **Mitigate Errors**
  - CONTINUING (WEEKLY) PHYSICS CHECKS & EOT CHECKS
- **Trap Errors**
  - INITIAL PLAN CHECKS
- **Avoid Errors**
  - PROGRESS, STANDARDIZATION, PRODUCTION, PROCESSES

QUALITY MANAGEMENT TAKE HOME

- Need to Take a Systems View
- Understand & Capitalize on Interconnections
- Appreciate the Role of Physics Plan Checks in Overall Process
QUALITY MANAGEMENT TAKE HOME

• Physics Plan Checks are Important Piece of Puzzle!
• However they should not replace “Doing it Right the First Time”

THE END

• Thank you for your time and attention!
REFERENCES & RECOMMENDED READING

• ACR–AAPM TECHNICAL STANDARD FOR THE PERFORMANCE OF RADIATION ONCOLOGY PHYSICS FOR EXTERNAL BEAM THERAPY
• Clarity PSO, AAPM and ASTRO, ROILS: Radiation Oncology Incident Learning System Q3 2016 Quaterly Report
• Clark, B. et al. Patient safety improvements in radiation treatment through 5 years of incident learning., Practical Radiation Oncology (2013) 3, 157–163
• Novak, A. et al., Targeting safety improvements through identification of incident origination and detection in a near-miss incident learning system, Med. Phys. 43 (5), May 2016
• Evans, J. and Lindsay, W. Managing for Quality and Performance Excellence, 8th ed., South-Western Cengage Learning.
• Evans, S. et al. Standardizing dose prescriptions: An ASTRO white paper. Practical Radiation Oncology (2016) 6, e369–e381

REFERENCES & RECOMMENDED READING

• Gopan, O. et al, The effectiveness of pretreatment physics plan review for detecting errors in radiation therapy, Med. Phys. 43 (9), September 2016
REFERENCES & RECOMMENDED READING


- Safety is no accident: A Framework for Quality Radiation Oncology and Care, American Society for Radiation Oncology. 2012.