Radiation Therapy Intelligent Simulation Design:
Innovative Training Methods to Increase Patient Safety

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Outline

• Introduction
• Errors/Deviations in Radiation Oncology
• Overview of USA Health Care Education
• Overview of Simulation Based Training
• Why/How Simulation Based Training Works
• Several UNC Published Papers
• Conclusions
Disclosures

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Statistics
Current Leading Causes of Death in the USA

1) Heart Disease
2) Cancer
3) Patient Errors

The Cause

• Systemic – How we educate and train medical professionals
  – *To Err is Human* estimated up to 100,000 preventable deaths almost 20 years ago
  – May be the greatest cause for 400,000 medical deaths per year today
Iatrogenesis
(Greek “brought forth by the healer”)

- 3.5 million medical errors associated with iatrogenic induced disabilities per year
  - Wrong prescription
  - Wrong site
  - Wrong patient
  - Drug interactions
  - Complications from procedures
  - Negligence
  - Under-treatment
  - Overtreatment
  - Hospital acquired infections
  - Medical errors

Flexner Report

1911 Changed Medical Education
2002 JRCERT Accreditation
1967 Allied Health Act

- Streamlined Medical and Allied Health Education
  - Are we using the same teaching techniques from years ago and expecting different results?
Basically not taken into account when designing health education curriculum

Other Industries

Aviation
Spatial Engineering

Past 15 years:

Have halved their error rates exclusively by incorporating and changing their educational curriculum models to include andragogy, evidence based education, and patient safety methods
Medical Simulation Based Training

1) Military Game Theory: Persia 1,500 years ago
2) Today, digital, even JAG used SBT
3) Aviation: 1929 blue box to flight simulators—10,000 feet rule
4) Astronauts: NASA TLX
SBT in Health Care

1) Middle Ages: Animals for Surgery
2) 1900: Paris, *mannequin obstétrical*
3) 1968: Paris, developed a plastic doll for air to air resuscitation (named Annie after girl who drowned in the Seine)
4) 1970 ‘Harvey’ doll developed CPR

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SBT in Health Care

5) 1970s: Introduction of Actors
6) 1980s: OSCE skill and time are introduced
7) 1990s Comprehensive Anesthesia Environment (CASE)
8) 2007 Implementation of Second Life in Medical Schools: Virtual History Taking
Simulation Based Training: 
*Why This Works*

A. Adult Based Training ‘enhances need to know’
B. Can be used to predict different scenarios within the training
C. Allows Problem Based Scenarios to become *more* complex and *more* complicated within a safe environment

Why this Works

- Debriefing is a key to SB learning:
  a) Reinforces core assumptions of adult learning
  b) Provides external motivation and stimulates guided reflection
  c) Understanding how the experience affects future practice is a crucial step to improve performance
Andragogy

- Simulation by itself does not guarantee learning,
- but within the proper environment,
- it is a tool of paramount importance for modern curricula oriented by the adult learning theory
Why Do This: First Reason

- Medical Ethics: ‘first, do no harm’
- 400,000 deaths in 2015
- 3.5 million incidents of patient harm
- Statistics are increasing; **NOT** decreasing
- SBT has metrics and “To Err is Human” advocates SBT in Health Care Education
Why Do This: Second Reason

• **Error Management and Prevention**

  • We seek perfection, but still use traditional pedagogical teaching/training methods
  
  • Error management involves understanding the nature and cause of errors in order to avoid further mistakes

Why Do This: Second Reason for *Error Management and Prevention*

• Flight simulators change conditions that induce errors and also on non-technical skills that can prevent them, such as optimal communication and teamwork behavior

• SBT has the potential to improve performance in core competences such as: knowledge, communication skills, team work, patient care, clinical skills and professionalism
Why Do This: Third Reason

- **Skills evaluation**
  - Changing the concept of standard evaluation to an analytical learning process is not an easy task.
  - SBT provides an objective way to analyze performance and substantiate feedback – a fundamental step for demonstrated continuous improvement.

Empowering Individuals for Reporting and Improvement

Program covers all aspects of change management so that your teams are empowered to identify opportunities and create successful change themselves.

- **Good Catches**
  - *5,000 submitted*

- **Metrics and Visual Mgmt**
- **Improvement Projects (A3’s)** and **Implementation Cycles (PDSA)**: *150 completed*

The front-line teams that actually deliver care have constant feedback on how their practices have a today impact on the quality and reimbursement metrics.
Health IT and Patient Safety
Building Safer Systems for Better Care

- Health IT can improve patient safety and quality of care and should be widely embraced (Bates 2003; Ash 2009).

- For example, Hill (2013) found that providers seeing (on average per hour) 2.4 patients require about 4,000 mouse-clicks in EHRs during a 10-hour shift.

- Reports focused on EHR-related medical malpractice identified over 80% of the reported events involve patient harm (Garber 2015).

However, little published evidence could be found quantifying the magnitude of the risk.
The Joint Commission Report on EHR-related errors (n=120)

- Policies & procedures: 6%
- Workflow and communications: 24%
  (high/variable workload)
- Usability: 33%
- Actions: 6%
- Harm

A complimentary publication of The Joint Commission
Issue 54, March 31, 2015

Time-line & Interactions with Computers

<table>
<thead>
<tr>
<th>Consultation</th>
<th>Planning</th>
<th>Physics QA</th>
<th>Treatment</th>
</tr>
</thead>
</table>

Iterations & Handoffs
IMRT case:
200+ steps,
many hand-offs
**Error rates**

<table>
<thead>
<tr>
<th>Deviation Rates (%)</th>
<th>Per treatment</th>
<th>Per Course</th>
<th>Per Fraction</th>
<th>Per Field</th>
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<tbody>
<tr>
<td><strong>Multiple Center Series</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>UK, 2006</td>
<td>0.04 (0.003)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pennsylvania State, 2009</td>
<td>0.0025 (0.0006)*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NY State, 2009</td>
<td>0.06 (0.01)*</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Single Institution Series</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Finazi, 1988</td>
<td>0.44</td>
<td>1.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mackie, 1998</td>
<td>3.06</td>
<td></td>
<td>0.18 (0)</td>
<td></td>
</tr>
<tr>
<td>Barthelme-Bracht, 1999</td>
<td>3.22</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Patton, 2003</td>
<td>0.17</td>
<td>3.3</td>
<td></td>
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<tr>
<td>Huang, 2005</td>
<td>1.97</td>
<td>0.29</td>
<td></td>
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<tr>
<td>Tsung, 2005</td>
<td>4.66</td>
<td>0.25</td>
<td></td>
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<tr>
<td>French, 2006</td>
<td>0.32 (0.05)*</td>
<td>0.037 (0.005)*</td>
<td></td>
<td></td>
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<tr>
<td>Marks, 2007</td>
<td>0.10</td>
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* Estimated severe error rate.
† NY state regions outside of the Metropolitan NY city area.

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**Studies & Results**

Error rate
≈ 5% of the >
≈ 800,000 patients receiving RT per year in the US;
‘Serious’ events occurring ≈ 1 of
1,000-10,000 patents


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*Marks et al., Practical Radiation Oncology 1(1), p1-14, 2011.*
Current lab

- VisionTrack ISCAN
- Tobii X-60
- SMI glasses
- BrainVision
- ABM EEG
- NeXus
- Epic Playground
- Mosaiq
- PLUNC
- Elekta Emulator
- Computers
- Printers
- Phones

Simulation-based Training to Enhance Patient Safety in Radiation Oncology

Assess Mental Workload & Performance

- Pre-intervention assessment: mental workload & performance
- Post-intervention assessment: mental workload & performance

Randomization to +/- simulation-based training

Randomization to +/- enhanced environment

Hypothesis #1: Providers exposed to simulation training will show an improvement in performance and more-optimal levels of mental workload.

Hypothesis #2: Enhancements to the user interface and cognitive workflow will be associated with an improvement in providers’ performance and with more-optimal levels of mental workload.
5 Principles for Effective Design and Use of Simulation-based training

- **#1:** Should be developed by a multi-disciplinary team that understand the context of the clinical care that the end-user is expected to provide.

- **#2:** Development of the competence of safety mindfulness should be technology and situation independent. It should be treated as a required characteristic of the individual.

- **#3:** Should range from simple (‘bread-and-butter’ like; perceived as low cognitive effort, with few unexpected events or unusual or abnormal occurrences; “I have seen/done this before”) to complex (‘fire-in-the cockpit’ like; perceived as high cognitive effort, including unexpected or abnormal events; “I have never seen/done this before”, “Wow – what just happened!”) cases.

- **#4:** Should be replicated, with some variations, over time to allow RT professionals to experience changes in cognitive effort and performance.

- **#5:** Evaluation should be based the elements of the definition of safety mindfulness.

Safety Mindfulness: Definition

- **High adherence to evidence-based medical procedures, including documentation and communication standards**

  - High: failures interact in a predictable manner and can be effectively mitigated via preemptive cognitive routines/strategies and pragmatic improvement behaviors.

  - Low: moment-by-moment appreciation of the potential for latent and active failures pathways.

- **Low adherence to evidence-based medical procedures, including documentation and communication standards**

  - High: failures interact in an unpredictable manner and cannot be effectively mitigated via preemptive cognitive routines/strategies and pragmatic improvement behaviors.

  - Low: moment-by-moment appreciation of the potential for latent and active failures pathways.
### Simulation-based training

#### Step 1: Introduction to the session:
- Review of ‘personal’ involvement in patient harm.
- Review key lessons learned from didactic training.

#### Step 2: Review of workload and performance:
- Refresh trainee of the scenario and bring up the evaluation scores.
- Emphasize concepts reviewed during didactic sessions
  - Workload → performance relationship
  - System I vs. System II Thinking
  - Swiss Cheese Model
  - Normal Accident Theory
  - ‘Lean’ concepts for continuous improvement

- Test if decisions were deliberate and thoughtful vs. lack of **safety mindfulness**.

Use this 2-part formula for debriefing participants' performance:
- **#1**: Always agree with the trainee’s objections if possible, and then build from there to reach the learning objectives.
- **#2**: State your concern explicitly, and then ask for their thought process.

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Training scenario:
Whole brain radiotherapy (WBRT)

- Patient with brain metastasis (emergency, palliation)
- History of prior radiation therapy to the head and neck (partial overlap)
Assessment scenario (complex): Radiation-induced sarcoma

- Patient with curable radiation induced abdominal sarcoma
- History of radiation therapy to abdomen (complete overlap)

Electronic Checklist to Support Safety Mindfulness

- Current Prescription
- Prior Treatments
- Fusion
- Timeline

Conclusions

1) Errors/Deviations continue to rise in health care delivery
2) Health Care curriculum still is Pedagogy Based
3) Successful high-risk Industries have incorporated SBT
4) UNC Radiation Oncology has completed several studies quantifying the linkage and success of SBT to decrease errors/deviations and increase positive outcomes
5) SBT is an emerging futuristic opportunity for educators/administrators/leaders in radiation oncology practice to design and implement outcomes based educational models
6) Being able to demonstrate positive outcomes and metric based learning is “the future”—it comes down to our will, our vision, and our need to know

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The Power of Engagement

Engineering Patient Safety in Radiation Oncology

University of North Carolina’s Pursuit for High Reliability and Value Creation

Lawrence Marks - Lukasz Mazur

Bhishamjit Chera - Robert Adams