Implementing CAST in Health Care
An overview of the methodological and infrastructure development

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A concerning safety performance

621 radiation therapy incidents in NY 2001 - 2008

- 46%, Missed target
- 41%, Wrong dose
- 5%, Other
- 8%, Wrong patient

Annually, 1 in 20 patients are exposed to preventable harm

$617 million excess cost in MA in a year

An estimated 160 million medication errors occur each year in primary care

55% of patients said diagnostic errors were a chief concern in outpatient visits
Current approach to learning is not effective

More surgical items being left inside patients blamed on rushed operations

‘I was in constant pain,’ says woman who had glove, sponges still inside her

News

Survey of UK doctors highlights blame culture within the NHS

*BMJ* 2018;362 doi: https://doi.org/10.1136/bmj.k4001 (Published 20 September 2018)

Root cause analyses (RCAs) are not generating the needed insights for safety improvement
Operational barriers to CAST application

Time

• 20-90 person-hours per RCA
• Little time for training

Knowledge

• No engineering/safety background
• Systems theory is foreign to most

How can we facilitate CAST application in health care?
Development to facilitate CAST application

CAST

Assemble Basic Information → Model Safety Control Structure → Analyze Each Component in Loss → Identify Control Structure Flaws → Create Improvement Program

Methodological development

A process to generate investigation questions

A graphical safety intervention design process

Artifact dev.

Ref. losses & hazards
Pre-built safety control structure
Reference controller responsibilities

Cases illustrating systemic factors

Reference CAST analysis of a contouring incident

Template & training dev.
Presentation Road Map

Reference CAST analysis of a contouring incident

Ref. losses & hazards
Pre-built safety control structure (SCS)
A process to generate investigation questions
A graphical safety intervention design process

Not covered in the interest of time
Reference controller responsibilities
Cases illustrating systemic factors
Template & training
A Reference CAST Analysis – Case Background

• Radiation oncology – provide radiation therapy for cancer
A Reference CAST Analysis – Case Background (2)

• Magnetic resonance imaging (MRI) improves treatment planning accuracy
A Reference CAST Analysis – A Contouring Incident

• 6-year-old
• Right-thigh sarcoma
• MRI fusion missed in treatment planning

Impact
• Target volume 30% larger than necessary
• Increased risk of growth delay & infertility
Presentation Road Map

Reference CAST analysis of a contouring incident

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Methodological development
Artifact development
Template & training development
## Reference losses and hazards

- 5 losses and 5 hazards

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Reference CAST analysis

Ref. losses & hazards

SCS

A process to generate investigation questions

A graphical safety intervention design process
## Using the reference losses and hazards

### Case description
Increased risk of growth delay & infertility; target volume 30% larger than necessary

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Methodological development
Artifact development
Template & training development
Pre-built safety control structure

• 8 views in total
  (from the top down, first 3 views shown)

• 39 controllers

• On the order of 100 control actions

• On the order of 100 feedback
Using the pre-built safety control structure

**Case description**
The treatment plan was created and approved without leveraging the available MR images

&

**Loss, hazard statements**

**Selecting the relevant SCS views and edit**
(rather than building SCS from scratch)

3 views incorporated with little modifications

- Society View
- Organization View
- RT Planning and Delivery View
Using the pre-built safety control structure (2)

Reference CAST analysis
Ref. losses & hazards
SCS
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Regulatory, certification, licensing, accreditation, advisory bodies

Regulate
Approve design
Request recall

Device design
Incident report

Regulate, license, accredit

Facility, operations condition
Incident report

TPS, EHR software manufacturers

Health care organization

Other health care org./provider

Complaint

Patient

Minor modification
Editing the generic “Device, software manufacturers” in pre-built SCS

Society View
Using the pre-built safety control structure (3)

RT Planning View – modified with mostly deletion

Reference CAST analysis  Ref. losses & hazards  SCS  A process to generate investigation questions  A graphical safety intervention design process
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Methodological development
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A process to generate investigation questions

- Controller-specific questions generated mostly by substitution

E.g., How did the <controller> choose to perform <control action; or between control action options>?
A process to generate investigation questions (2)

Treatment Planner
Responsibility relevant to this safety incident
• Fusion and registration (primary)

Contribution to the hazardous state
• Did not fuse MR image to CT for contouring

Investigation question:
How did the Treatment Planner choose to perform MR image fusion or not?
A process to generate investigation questions (3)

Other controller-specific questions are generated similarly

What was the `<controller>`’s understanding of the contemporaneous `<process>` state?
...

**Diagram:**
- Human Controller
- Control Action Generation/Mental Processing
- Mental Models
  - Model of Automation
  - Model of Other Controllers
  - Model of Environment
  - Model of Controlled Process
- Sensory Feedback & Inputs

**Reference:** CAST analysis, Ref. losses & hazards, SCS, A process to generate investigation questions, A graphical safety intervention design process.
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A graphical safety intervention design process

Causal factors → Safety constraints → Mapping to SCS → A marked up SCS → Detailing safety intervention ideas → Safety intervention

- Identify objective/intent without the means
- Locate a broad set of candidate interactions
- Instantiate a safety intervention idea
A graphical safety intervention design process (2)

1. Defining safety constraints at multiple hierarchical levels

**Treatment Planner**

Process model flaw
• Did not know the need to fuse the MR image

Contextual/process model factors
• A physician order was required for MR image fusion... The original planning request did not include the fusion order.
• The TPS did not require MR image fusion before plan completion.
• ...

C-SC-1. Dosimetrist must know definitively the need for MR image fusion at the start of treatment planning.

... C-SC-3. Treatment planning team members must be informed of any deviation from normative practices.

(C-SC = for Component-Safety Constraint)
A graphical safety intervention design process (3)

1. Defining safety constraints at **multiple** hierarchical levels

“Dose must be delivered to the right patient at the right amount and location.”

A-SC-1. RT planning must incorporate clearly defined soft tissue boundaries when indicated.

(A-SC = Abstracted-Safety Constraint)

2. Identify the intervening hierarchical levels

C-SC-1. Dosimetrist must know definitively the need for MR image fusion at the start of treatment planning.

Reference CAST analysis

Ref. losses & hazards

SCS

A process to generate investigation questions

A graphical safety intervention design process

Notional hierarchical level
A graphical safety intervention design process (4)

2. Map the safety constraints to the safety control structure

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C-SC-1. Dosimetrist must know definitively the need for MR image fusion at the start of treatment planning.
A graphical safety intervention design process (6)

• 3. Detail safety intervention ideas by
  a) Identifying the interaction(s) of opportunity, and
  b) Specifying the means of fulfillment

C-SC-1. Dosimetrist must know definitively the need for MR image fusion at the start of treatment planning.

Means of fulfillment:
Modify Rx template to require justification if MR image fusion is to be omitted
A graphical safety intervention design process (7)

3. Detail safety intervention ideas by
   a) Identifying the interaction(s) of opportunity, and
   b) Specifying the means of fulfillment

C-SC-1. Dosimetrist must know definitively the need for MR image fusion at the start of treatment planning.

Means of fulfillment: Safety committee to audit justification for MR fusion omission every month.

Means of fulfillment: Allow MR image fusion omission only for patient-based reasons.
A graphical safety intervention design process (8)

Facilitating design for **hazard elimination**

Abstracted safety constraint

A-SC-1. RT planning must incorporate clearly defined soft tissue boundaries when indicated.

Means of fulfillment: MRI-only treatment planning

Component-level safety constraint

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SCS

A process to generate investigation questions

A graphical safety intervention design process

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Reduced task cognitive complexity for novices
## Summary

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Efficient, consistent CAST application in health care
Next steps

A field test

• Implementation at UCSD Moores Cancer Center
• Comparison studies
  • Causal factors
  • Safety intervention recommendations
• Usability study
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Thank you

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