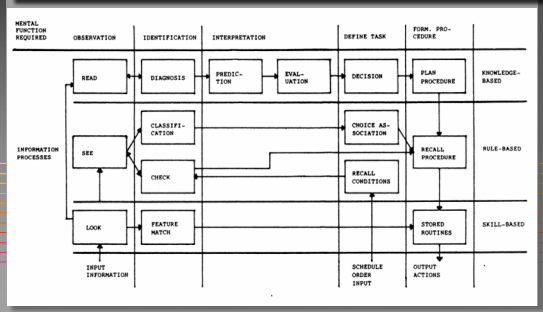
Errors in Radiotherapy

Bruce Thomadsen
Shi-Woei Lin

University of Wisconsin - Madison

Rasmussen's Performance-based Actions



Errors

- Systematic Errors:
  - Usually one mistake tucked into the procedure
  - Affects all, or a large class of patients.
  - Often found in Process Audit
  - Must be rooted out
- Random Errors:
  - Happen on a per-patient basis
  - May be caught through QM
  - Will never be eliminated (because of creativity)

One Example of Error Analysis in Radiotherapy

- We did a study of brachytherapy errors based on all misadministrations reported to the NRC.
- We performed several analyses of the events.

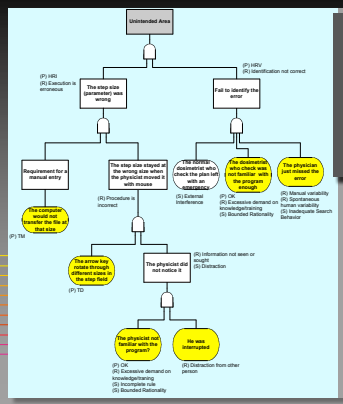
Caveat

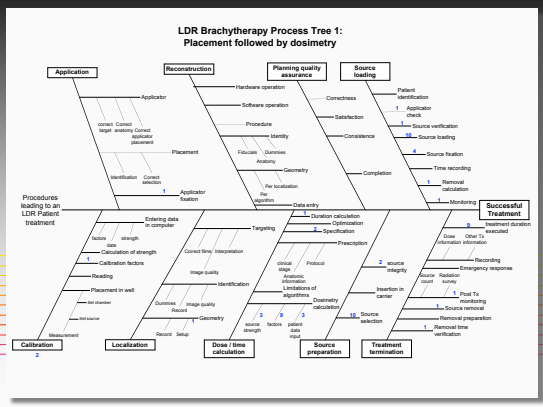
- The NRC does NOT keep any records of physician errors in diagnosing or prescribing. That, they say, would be dictating medicine.
- The only data is on deviations from prescriptions.

Analysis

- We constructed a process tree for the procedure.
- We constructed a fault tree for the procedure.
- For each event, we:
  - Contacted the principal and got the facts.
  - Constructed a root-cause analysis tree.
  - Marked the position of the failure on the fault and process trees.
  - Classified the events using three taxonomies.

Example Root-cause-analysis Tree





Conclusions from Process Tree Analysis 1

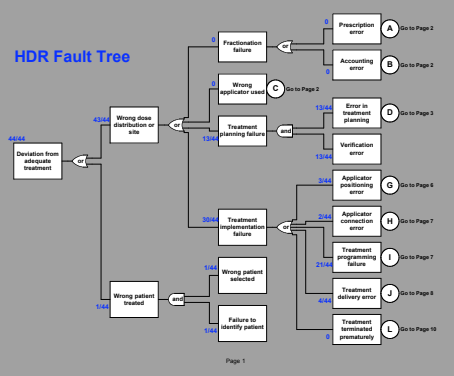
- For HDR
  - By far the most common step with failure was entering the treatment distance, usually not changing the default value.
  - Almost all steps in treatment unit programming or delivery had some errors.
  - Dose specification accounted for several errors.
  - The only problems with source calibration were in entering the calibration data into the treatment planning computer.

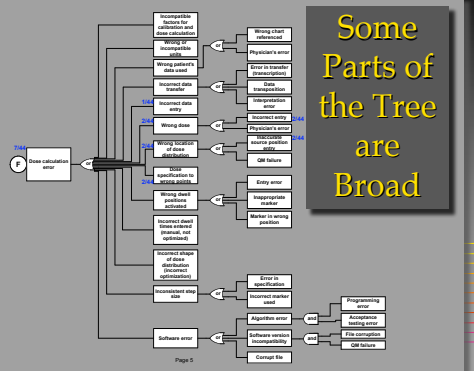
Conclusions from Process Tree Analysis 2

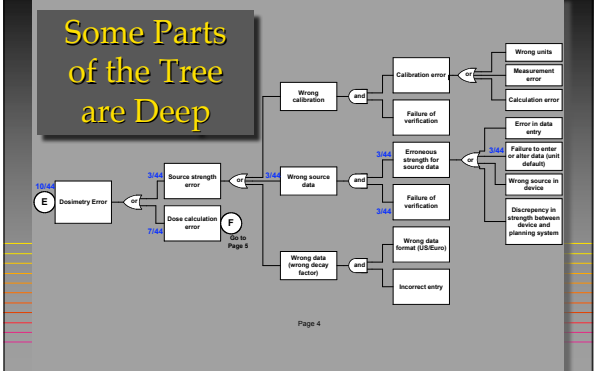
- For LDR (placement followed by dosimetry)
  - Errors in four steps accounted for most of the events:
    - » Selection of the sources,
    - » Loading of sources into the applicator,
    - » Using the required units when entering data into the computer, and
    - » Fixing the sources in the applicator, or applicator in the patient.
  - Most steps in "Source Loading," "Dose/time calculation," and "Treatment termination" had errors.

Conclusions from Process Tree Analysis 3

- For LDR (Dosimetry followed by placement), errors occurred only in
  - source preparation (usually ordering), and
  - source delivery (usually a failure to monitor).







Summary from HDR Fault Tree Tabulation

- 2/3 errors in delivery
  - 40% of errors due to default value for distance not being changed.
  - Applicator shifting in patient was only other frequent problem in delivery.
- 1/3 errors in treatment planning
  - 16% of errors in calculation, but of various types.
  - 7% of errors due to incorrect source strength entry.
- Almost all events had failures in verification.

Summary from LDR Fault Tree Tabulation 2

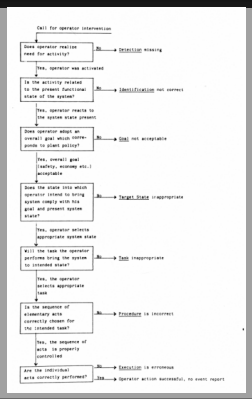
- 1/4 errors in treatment planning
  - 15% of errors in calculation,
    - » 11% due to incompatible units.
  - 8% of errors due to incorrect source strength entry.
- Again, almost all events had failures in verification.

Summary from LDR Fault Tree Tabulation

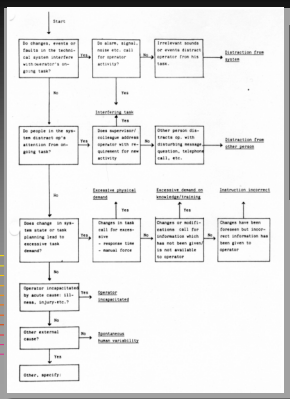
- 3/4 errors in delivery
  - 11% because the patient removed the sources and the staff didn't notice or correct.
  - 12% because the sources were never placed in the applicator correctly.
  - 14% because the wrong source strengths were used.
  - 8% because the physician placed the applicator incorrectly.

Analysis Based on Taxonomies

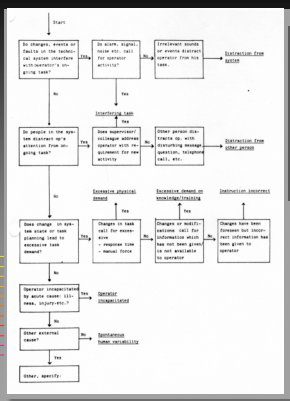
- Taxonomies, as you have heard, are ordered and organized classifications.
- They often can give insight into the nature of the errors occurring.
- While we looked at several, and developed our own, we will just present two today.



Rasmussen's What Happened Pathway



Rasmussen's Why It Happened Pathway



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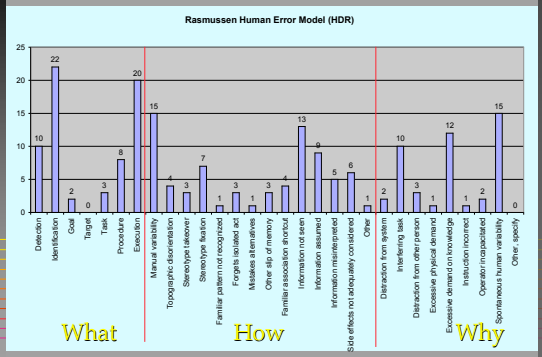


Conclusions from Taxonometric Analysis 1

From Rasussen's Model: "What"

- For both HDR and LDR, noticing the problem was the most significant variable.
  - For HDR, mostly the problem was identifying the problem using verification procedures in place (either they were not adequate or not performed).
  - For LDR, mostly there were no procedures in place to look for problems.
- For both HDR and LDR, the next ranking failure was in the execution of procedures,
- Followed by the procedures being wrong.

Conclusions from Taxonometric Analysis 2

From Rasussen's Model: "How"

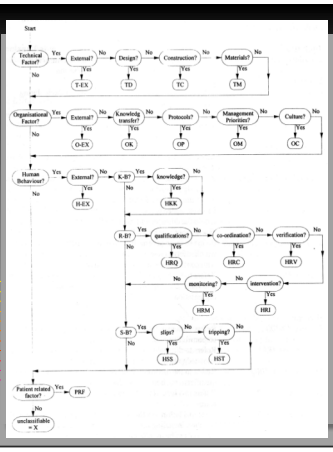
- From both HDR and LDR, the single most common failure is "manual variability".
  - This is probably an artifact of the model, which expects a human reactions to a plant problem.
  - This reflects that the initiating events in medicine is usually some person's action.
- Grouped, Stereotype responses come close.
- Information not seen, assumed or misinterpreted also was significant; for HDR they formed the dominant failure modes.

Conclusions from Taxonometric Analysis 3

From Rasussen's Model: "Why"

- These categories were not codable for many events.
- The most common classification was the catchall "Spontaneous human variability".
- "Excessive demand on knowledge" was significant, particularly for HDR, which is more technical.
- Interfering tasks were also important in HDR, which in more intensive at a given time.

SMART Pathway



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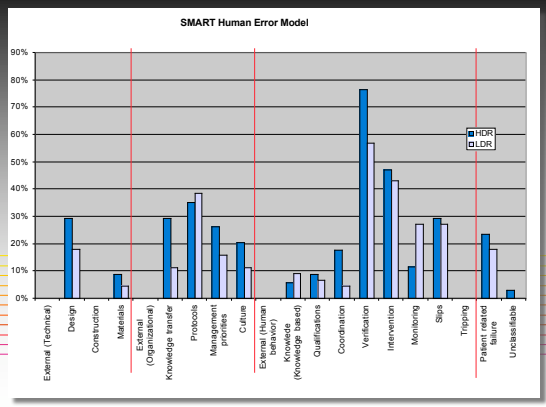

SMART's Suggested Actions

	Equipment	Procedures	Information & Communication	Training	Motivation
TE	X				
TC	X				
(TM)					
OP		X			
(OM)					
HK1			X		no!
HK2			X		no!
HR1				X	
HR2				X	
HR3				X	
HR4				X	
HR5				X	
HR6				X	
HS1	X				no!
HS2	X				no!

Conclusions from Taxonometric Analysis 4

From the SMART model: The results are very similar for both LDR and HDR.

- By far, the dominant failure mode was "Verification failure", followed by "Intervention" (which was scored if someone just goofed).
- Inadequate "Protocols" (i.e., procedures) were important, particularly in LDR. Also in LDR, lack of "Monitoring" was a common problem.

Conclusions from Taxonometric Analysis 5

From the SMART model: (Continued)

- Of about equal importance, "Knowledge transfer " (training), "Management priorities" (lack of staffing), and "Culture" (disregard for safety procedures) each showed up as important.
- Design was a common problem, as as was noted by all the other analyses.

Conclusions from Taxonometric Analysis 6

- Very few of the events involved knowledge-based errors.
- While the taxonomies tested did give useful information, they obviously did not match the medical setting well.

Overall Conclusions 1

1. Evaluation of a medical procedure using risk analysis provides insights.
2. Failure to consider human performance in the design of equipment led to a large fraction of the events reviewed.
   - While the equipment per se did not fail, the design facilitated the operator to make mistakes that resulted in the erroneous treatments.
   - Of particular danger were those situations where equipment malfunctions force operators to perform functions usually executed automatically by machines.
   - Entry of data in terms of units other than those expected by a computer system also accounted for several events.

Overall Conclusions 2

3. HDR brachytherapy events tended to happen most with actions having the least time available.
4. LDR brachytherapy, the most hazardous steps in the procedure entailed:
   - selecting the correct sources to place in the patient,
   - setting the sources in place properly in the patient and keeping them in place.
   - These events mostly result from lack of attention at critical times.

Overall Conclusions 3

5. Many events followed the failure of persons involved to detect that the situation was abnormal, often even though many indications pointed to that fact.
6. Once identified, the response often included actions appropriate for normal conditions, but inappropriate for the conditions of the event.

Overall Conclusions 4

7. Lack of training (to the point that persons involved understand principles) and
8. Lack of procedures covering unusual conditions likely to arise (and sometimes, just routine procedures) frequently contributed to events.
9. New procedures, or new persons joining a case in the middle also present a hazard.
   - 7/46 evaluable in LDR.
   - 12/38 evaluable in HDR.

Overall Conclusions 5

10. Most of the events suffered from ineffectual verification procedures, a failure noted by all three taxonomies. For the most part, improved quality management would serve to interrupt the propagation of errors by individuals into patient events.

Observations on Common Causes of Events

- Failures in medicine parallel those in industry.
- Errors don't just happen from a single cause, but are surrounded by complicating situations.
- Distraction (due to pressures and other assignments)
- Rushing (due to pressures and *lack of staffing*)
- Lack of communication (between parties)

Analysis of External-beam Events

The events fall clearly into categories:

- Random errors in a patient treatment
  - Few calculation errors (where much of QA falls)
  - Frequent errors when treatments are odd (e.g., odd angles used in the wrong direction)
  - Not uncommon following a change in prescription mid-course.
  - Not checking patient set-up after pause or interruption.

Analysis of External-beam Events (continued)

- Systematic errors
  - Errors in commissioning or calibration (note: the *errors* themselves are random, but propagate as systematic).
  - Errors in formulae
  - Errors in data entry or use of incorrect units
  - Usually there has been no verification or check of the data (strange, that we now always check a single patient's calculation, sometimes several times)

Commonalty in Most Events

The persons involved often fall into traps, set by the practice environment, and respond like human beings.