Prevention of Incidents in Radiotherapy

ICTP School on Medical Physics for Radiation Therapy

Dosimetry and Treatment Planning for Basic and Advanced Applications

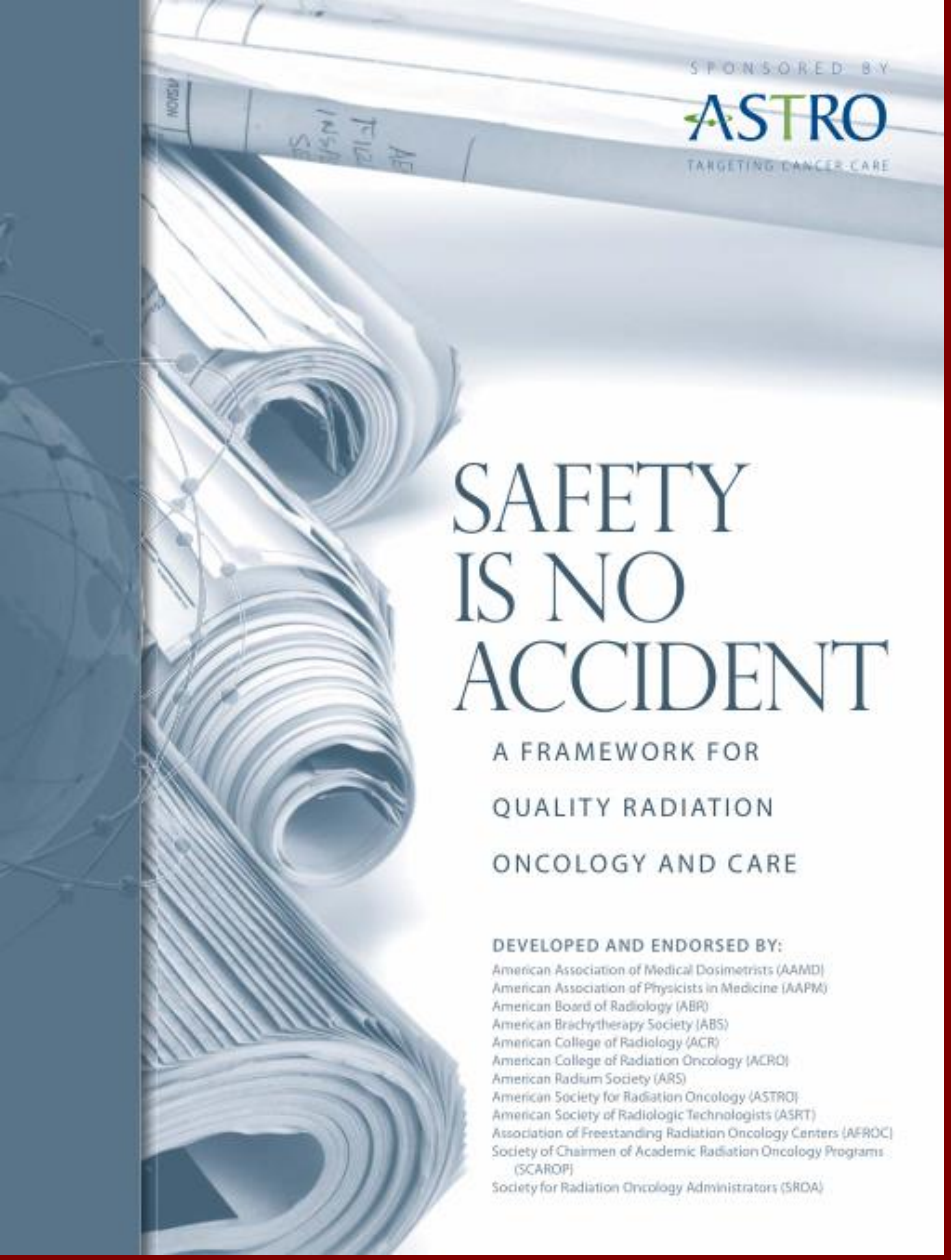
March 27 – April 7, 2017

Miramare, Trieste, Italy

Yakov Pipman, D.Sc.

What did we learn?

- Accidents happen
- When they happen there is more than one factor
- Many more ‘almost accident’s than big ones
- Common factors:
  - Training,
  - Communication, internal and external
  - Barriers,
  - Authority To Question (or lack thereof)
  - Lack Of Redundancies
  - Distractions / Attention
  - Procedural Variations
- Lack of clarity in analysis and reports of what happened



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www.practicalradonc.org

Special Article

Improving patient safety in radiation oncology

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Received 5 November 2010; accepted 12 November 2010

Abstract Beginning in the 1990s, and emphasized in 2000 with the release of an Institute of Medicine report, health care providers and institutions have dedicated time and resources to reducing errors that impact the safety and well-being of patients. However, in January 2010, the first of a series of articles appeared in *The New York Times* that described errors in radiation oncology that grievously impacted patients. In response, the American Association of Physicists in Medicine and the American Society for Radiation Oncology sponsored a working meeting entitled "Safety in Radiation Therapy: A Call to Action." The meeting attracted 400 attendees, including medical physicists, radiation oncologists, medical dosimetrists, radiation therapists, hospital administrators, regulators, and representatives of equipment manufacturers. The meeting was co-hosted by 14 organizations in the United States and Canada. The meeting yielded 20 recommendations that provided a pathway to reducing errors and improving patient safety in radiation therapy facilities everywhere.

The problem

In the early 1990s, articles began to appear in the scientific literature[1,2] describing the frequency of medical mistakes that place patients at risk. Soon thereafter, reports surfaced in the public media regarding medical errors (eg, chemotherapy overdose, wrong-sided surgery, anesthesia error) that caused the death or severe disability of patients. Partly in response to these reports, an international conference was held in 1993 (in Rancho Palos Verdes, CA) to examine the causes and consequences of severe errors in medicine. The conference was hosted by the American Medical Association and had several organizational co-sponsors. This conference spawned the National Patient Safety Foundation[3] and several other initiatives (eg, the Veterans Administration National Patient Safety Partnership) that devoted substantial resources to the identification and mitigation of medical errors. The National Academy of Sciences Institute of Medicine formed the Committee on Quality of Health Care in America that published a seminal report in 2000, entitled "To Err is Human: Building a Safer Health System."[4] This report estimated that between 44,000 and 98,000 patients died in the United States in 1997 as a consequence of medical errors, and it captured the attention of health care providers and public interest groups. For the past decade, programs to reduce medical errors have been established in most of the nation's hospitals and health care organizations.

Errors are known to occur in radiation oncology. The treatment of cancer patients with radiation is complicated for several reasons: the complexity of the disease, the sophistication of the technologies employed, the

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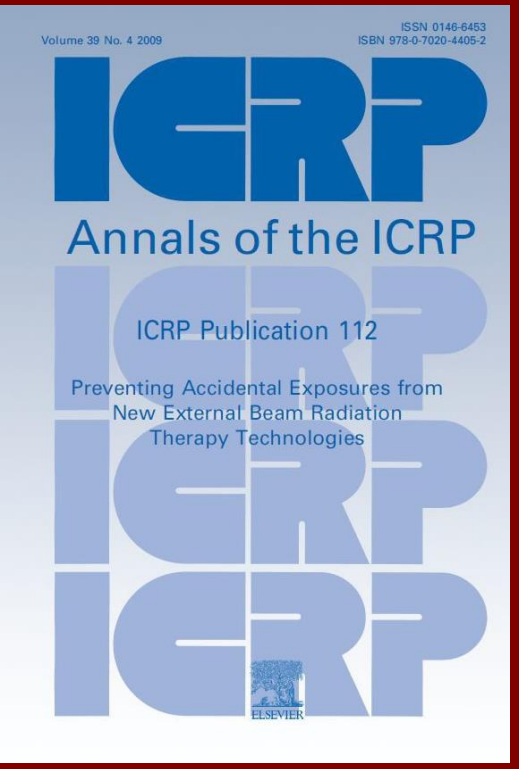
doi:10.1016/j.prro.2010.11.003

Zietman et al. 2012

Hendee and Herman 2011


ISSN 0146-6453
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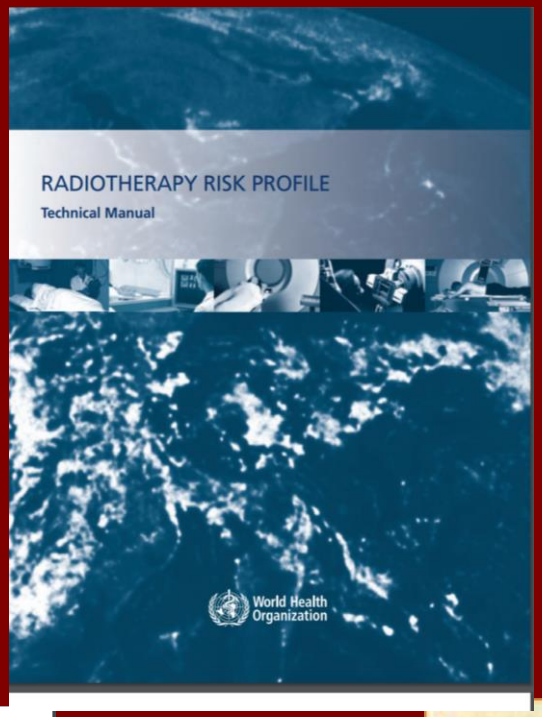
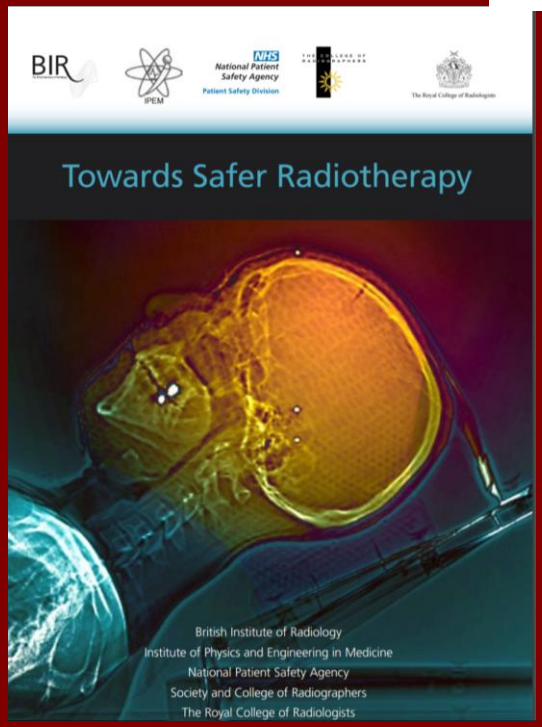
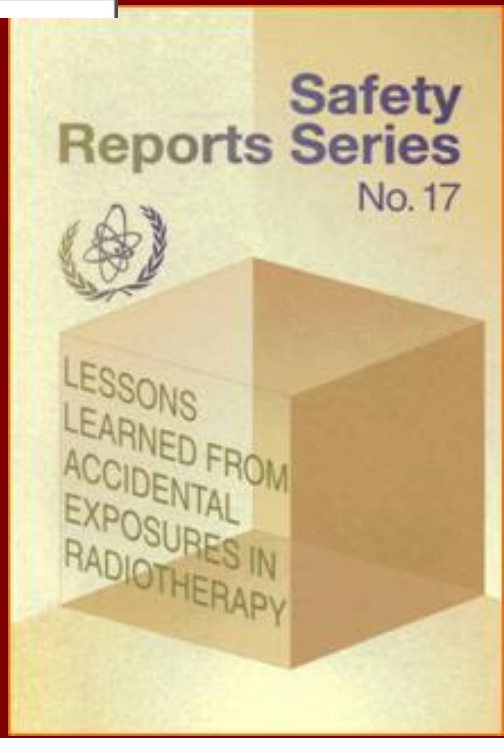
ISBN 978-0-7020-4405-2
ICRP
Annals of the ICRP
ICRP Publication 112
Preventing Accidental Exposures from New External Beam Radiation Therapy Technologies
ELSEVIER


RADIOTHERAPY RISK PROFILE
Technical Manual
World Health Organization


BIR
IPEM
NHS
National Patient Safety Agency
Patient Safety Division
The Royal College of Radiologists
Towards Safer Radiotherapy
British Institute of Radiology
Institute of Physics and Engineering in Medicine
National Patient Safety Agency
Society and College of Radiographers
The Royal College of Radiologists


Safety Reports Series
No. 17
LESSONS LEARNED FROM ACCIDENTAL EXPOSURES IN RADIOTHERAPY

What can we do?

Abundant Recommendations

Report	Advice
Towards safer Radiotherapy	*37*
Radiotherapy Risk Profile	*15*
Preventing Accidental …..	*15*
Hendee and Herman	*20*
Heirarchy of Actions	*19*
ASTRO	*6*
TG 100	*5*
Total	**117**

frontiers in ONCOLOGY

REVIEW ARTICLE
published: 28 September 2012
doi: 10.3389/fonc.2012.00129

Recommendations for safer radiotherapy: what's the message?

*Peter Dunscombe**

Education/ Training (7)

Staffing/skills mix(6)

Documentation/SOP (5)

Incident Learning System (5)

Communication/questioning (4)

Check lists (4)

QC and PM (4)

Dosimetric Audit(4)

Accreditation (4)

Minimizing interruptions (3)

Prospective risk assessment (3)

Safety Culture (3)

What can we do?

Education and Training

Multilayered prevention

Risk assessment – (FMEA)

Learning and Reporting Systems

Analyzing – Root Cause Analysis (RCA)

Safety Culture

IAEA Training Course

https://rpop.iaea.org/RPOP/RPoP/Content/AdditionalResources/Training/1_TrainingMaterial/AccidentPreventionRadiotherapy.htm

PREVENTION OF ACCIDENTAL EXPOSURE IN RADIOTHERAPY

Part 5: Reporting, investigating and preventing accidental exposures

IAEA
International Atomic Energy Agency

Preventing accidental exposures

- **Communication**

There should be clear and concise written rules for communication critical to safety. These rules should be posted and understood.

- Example: Handing over an accelerator to a physicist following maintenance should be formalized and adhered to. (e.g. case history on incorrect repair followed by insufficient communication – Spain, 1990)

Documents critical to safety, for example prescriptions, basic data and treatment plans, should be signed by staff who are responsible and qualified.

Multilayered prevention of accidental exposures

- The term "defence in depth" is defined in the BSS as "the application of more than one single protective measure for a given safety objective such that the objective is achieved even if one of the protective measures fail".

- "Defence in depth" can be viewed as several layers of safety provisions, such as physical components and procedures.

Multilayered prevention of accidental exposures

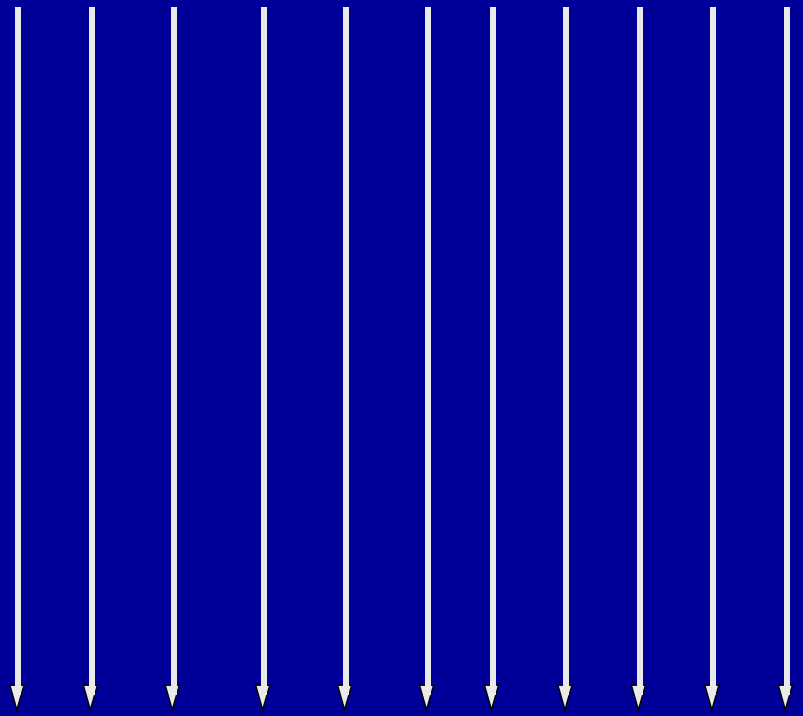
- Multilayered prevention includes aspects of “defence in depth” but also includes aspects such as awareness and alertness which could be termed “conceptual defence”

- For this multilayered prevention of accidental exposures to work, these layers need to be independent of each other.

- An implemented Quality Assurance program might provide the layers. Part of the QA should be to verify that this is the case!

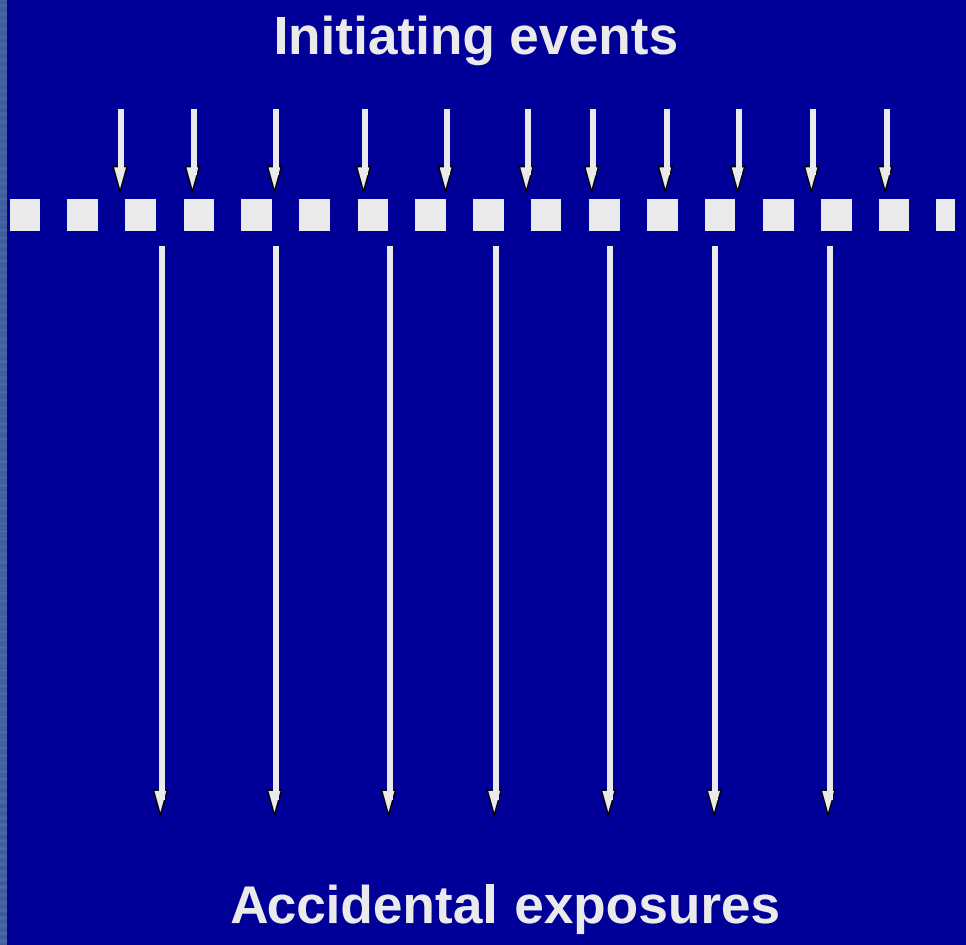
Multilayered prevention of accidental exposures

Initiating events will happen many times in any clinic



If there are no layers of safety provision, these events will lead to accidental exposures

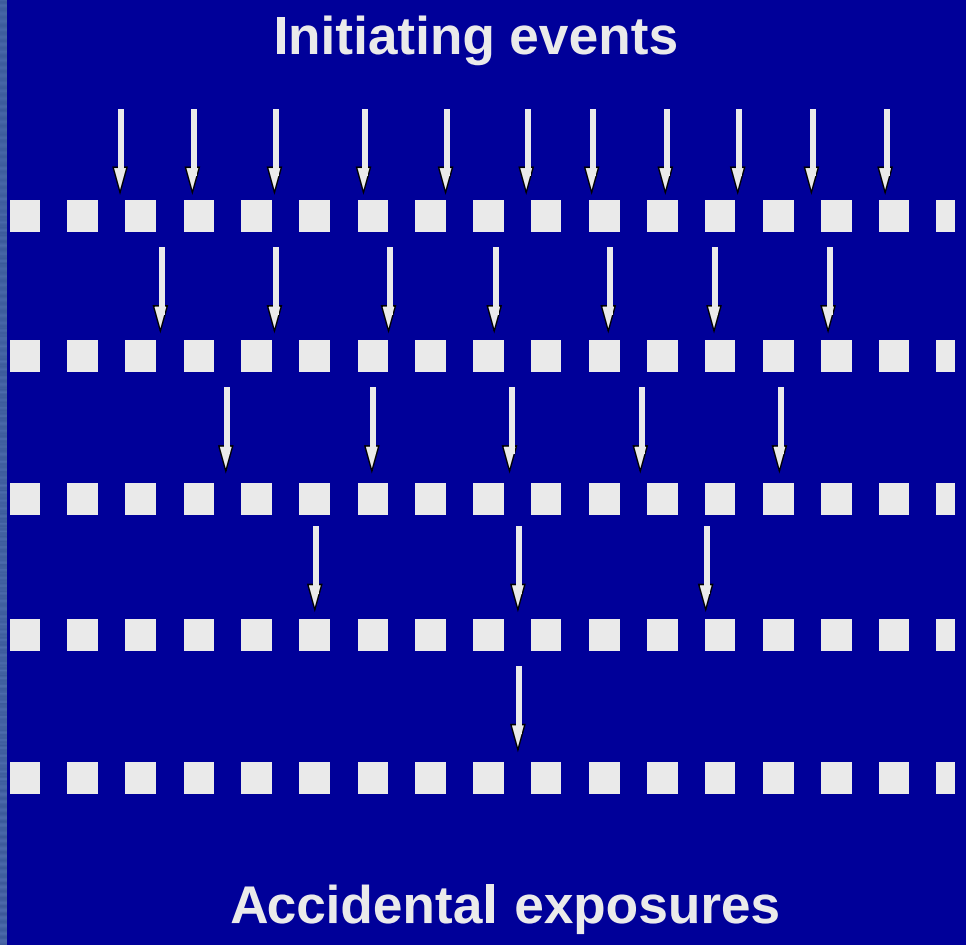
Multilayered prevention of accidental exposures



By putting in a layer of safety-provision, many initiating events are stopped from becoming accidental exposures.

When only a single layer of safety-provision is present, failure of this layer can still lead to accidental exposures.

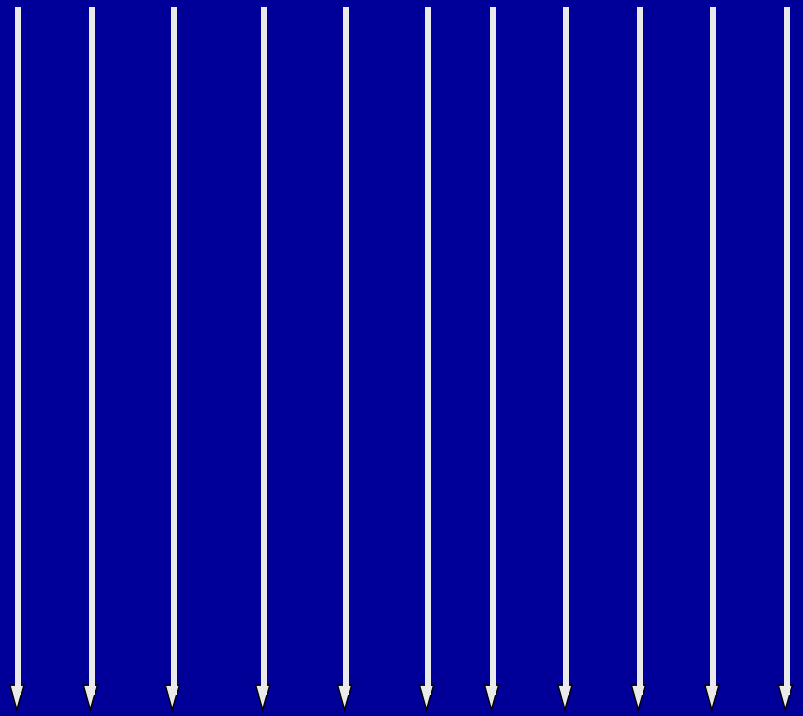
Multilayered prevention of accidental exposures



By having multiple <u>independent</u> layers of safety-provision, there is a much higher likelihood that accidental exposures are prevented.

Multilayered prevention of accidental exposures

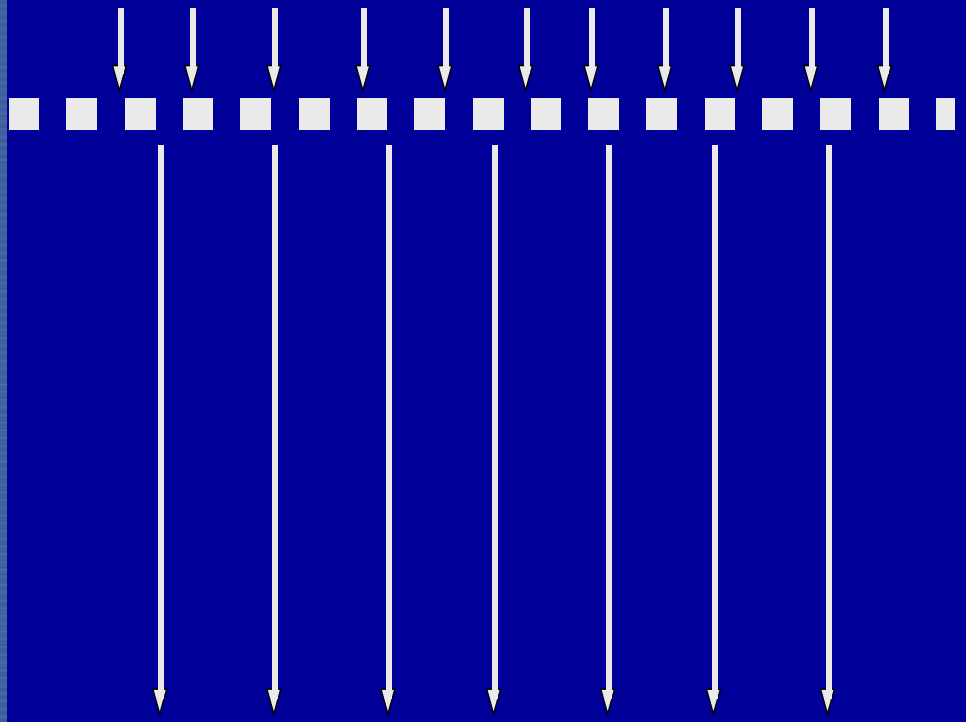
Initiating event: Mistakenly inverting SSD-correction in MU-calculation



Consequence: Very significant dose deviation for a patient

Multilayered prevention of accidental exposures

Initiating event: Mistakenly inverting SSD-correction in MU-calculation

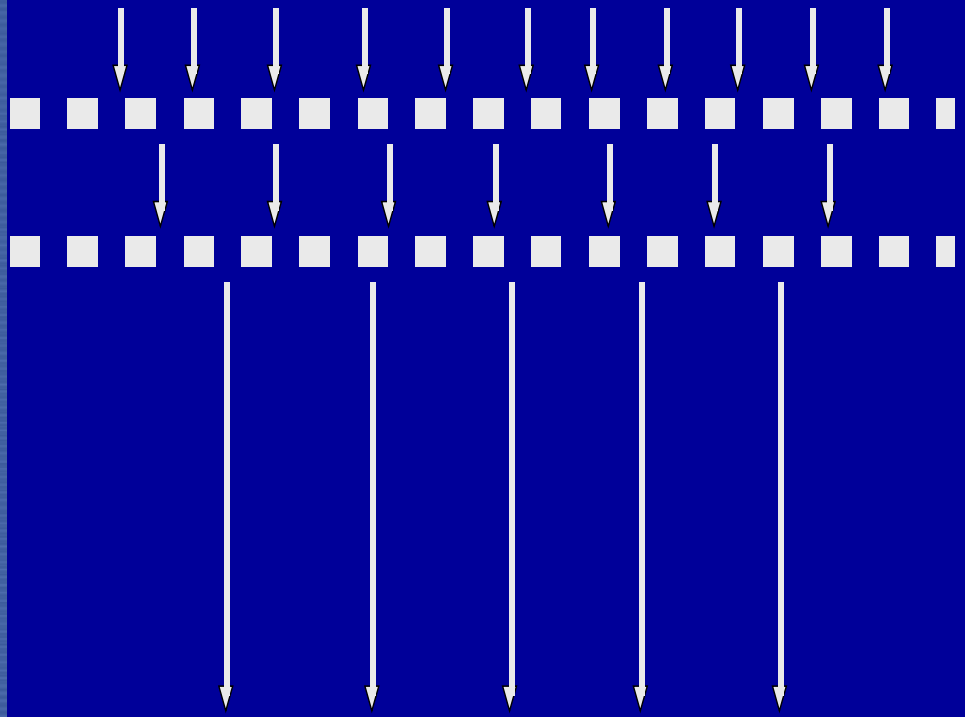


Independent check of calculation

Consequence: Very significant dose deviation for a patient

Multilayered prevention of accidental exposures

Initiating event: Mistakenly inverting SSD-correction in MU-calculation



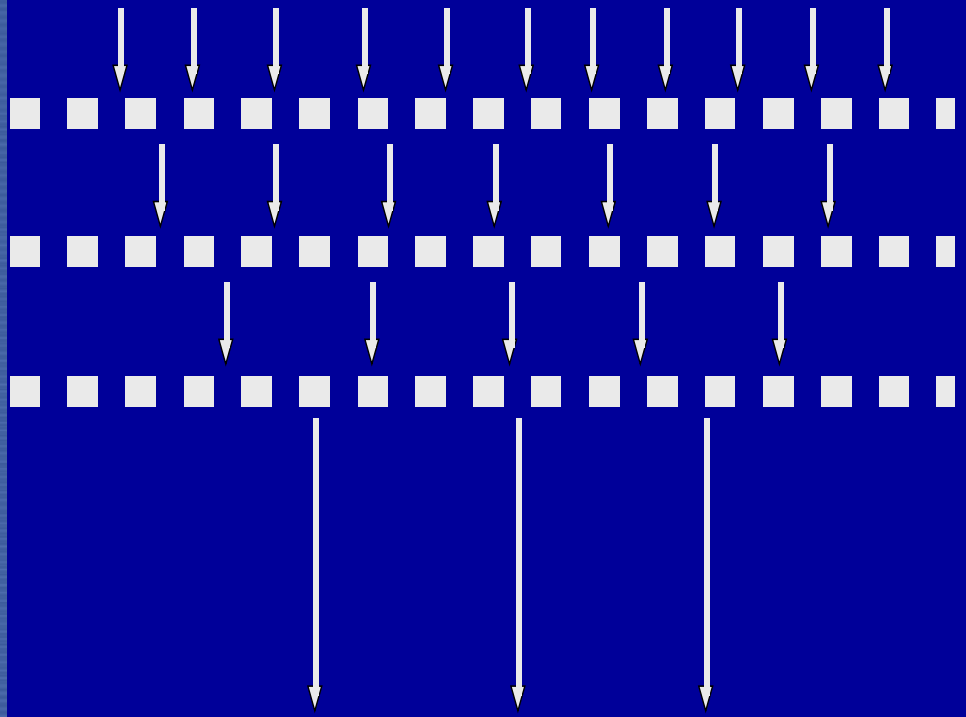
Independent check of calculation

Weekly chart-check of “reasonability”

Consequence: Very significant dose deviation for a patient

Multilayered prevention of accidental exposures

Initiating event: Mistakenly inverting SSD-correction in MU-calculation



Independent check of calculation

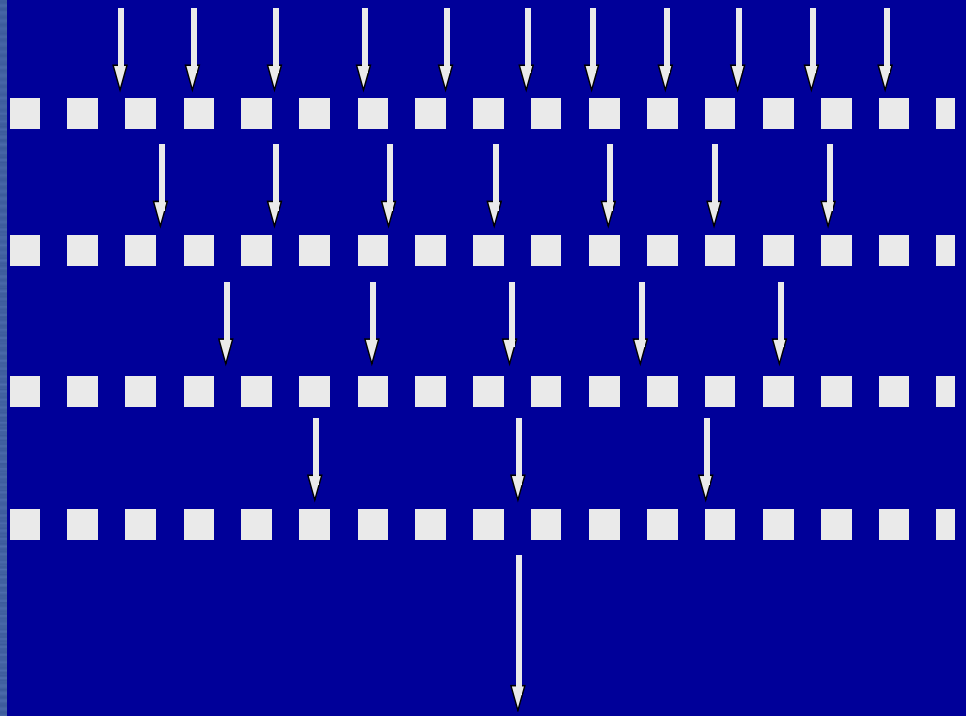
Weekly chart-check of “reasonability”

In vivo dosimetry

Consequence: Very significant dose deviation for a patient

Multilayered prevention of accidental exposures

Initiating event: Mistakenly inverting SSD-correction in MU-calculation



Independent check of calculation

Weekly chart-check of “reasonability”

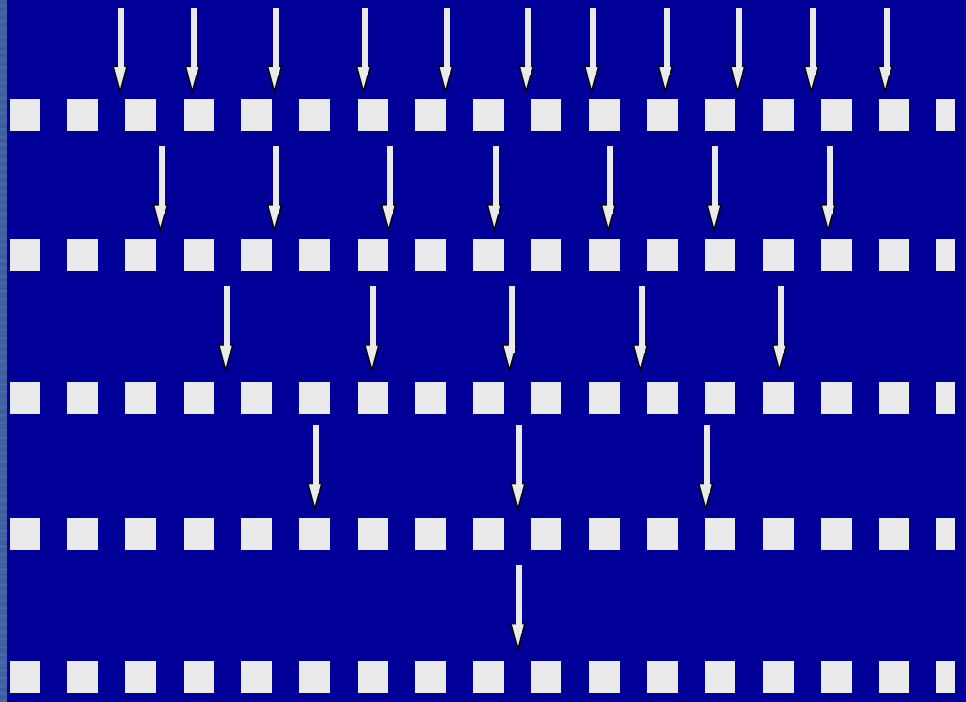
In vivo dosimetry

Written procedure for calculation methods

Consequence: Very significant dose deviation for a patient

Multilayered prevention of accidental exposures

Initiating event: Mistakenly inverting SSD-correction in MU-calculation



Independent check of calculation

Weekly chart-check of “reasonability”

In vivo dosimetry

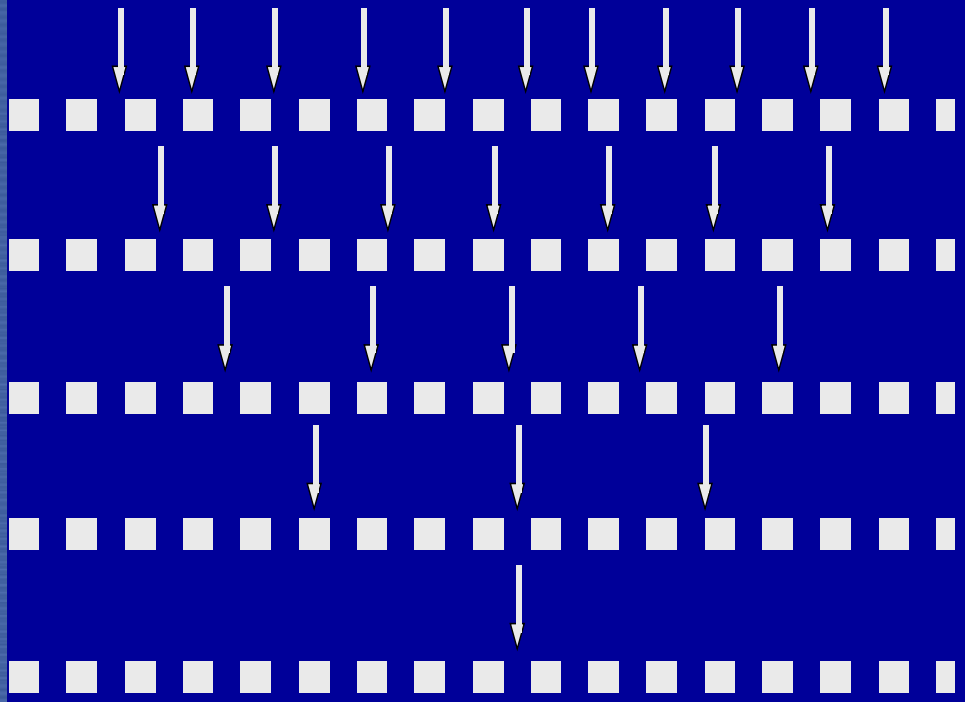
Written procedure for calculation methods

Awareness! Shorter SSD means shorter treatment time for same dose

Consequence: Very significant dose deviation for a patient

Multilayered prevention of accidental exposures

Initiating event: ?



Consequence: ?

<u>TRY IT AS AN EXERCISE!</u>

Examples of initiating events:

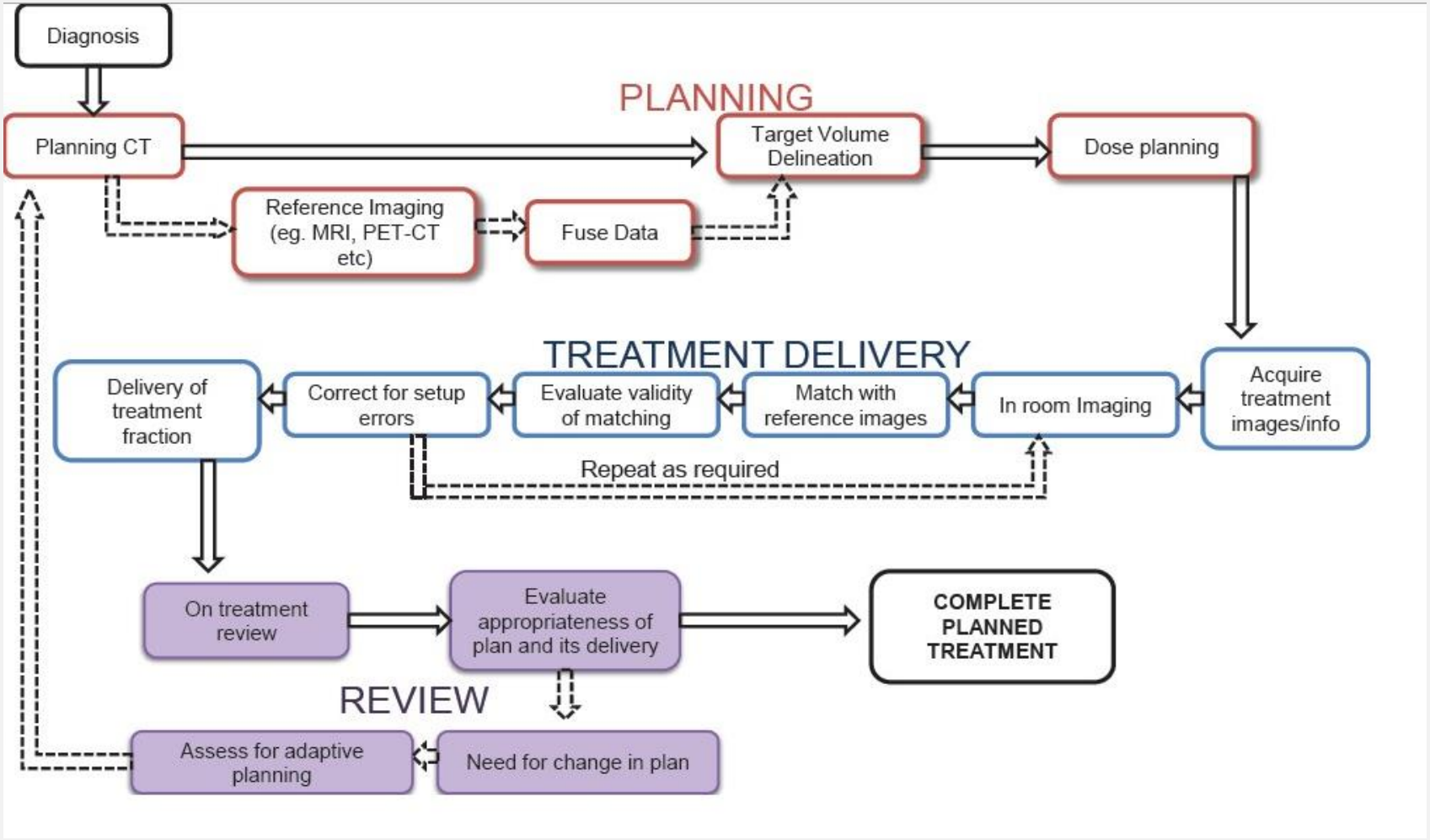
Calibration of beam made in penumbra

Pancake chamber used upside down

Use of wedge factor twice in calculation of treatment time

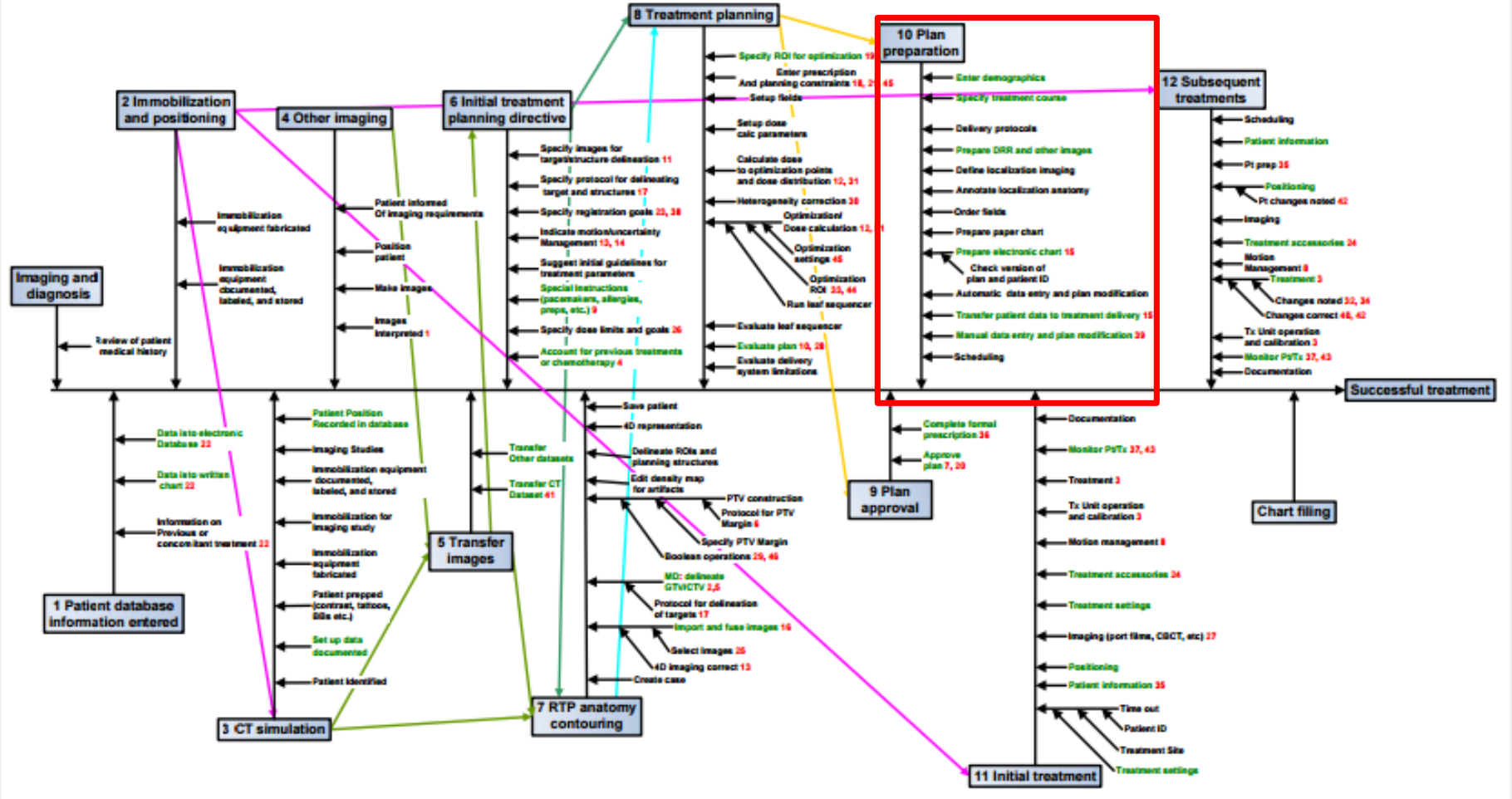
Misunderstanding of verbal prescription

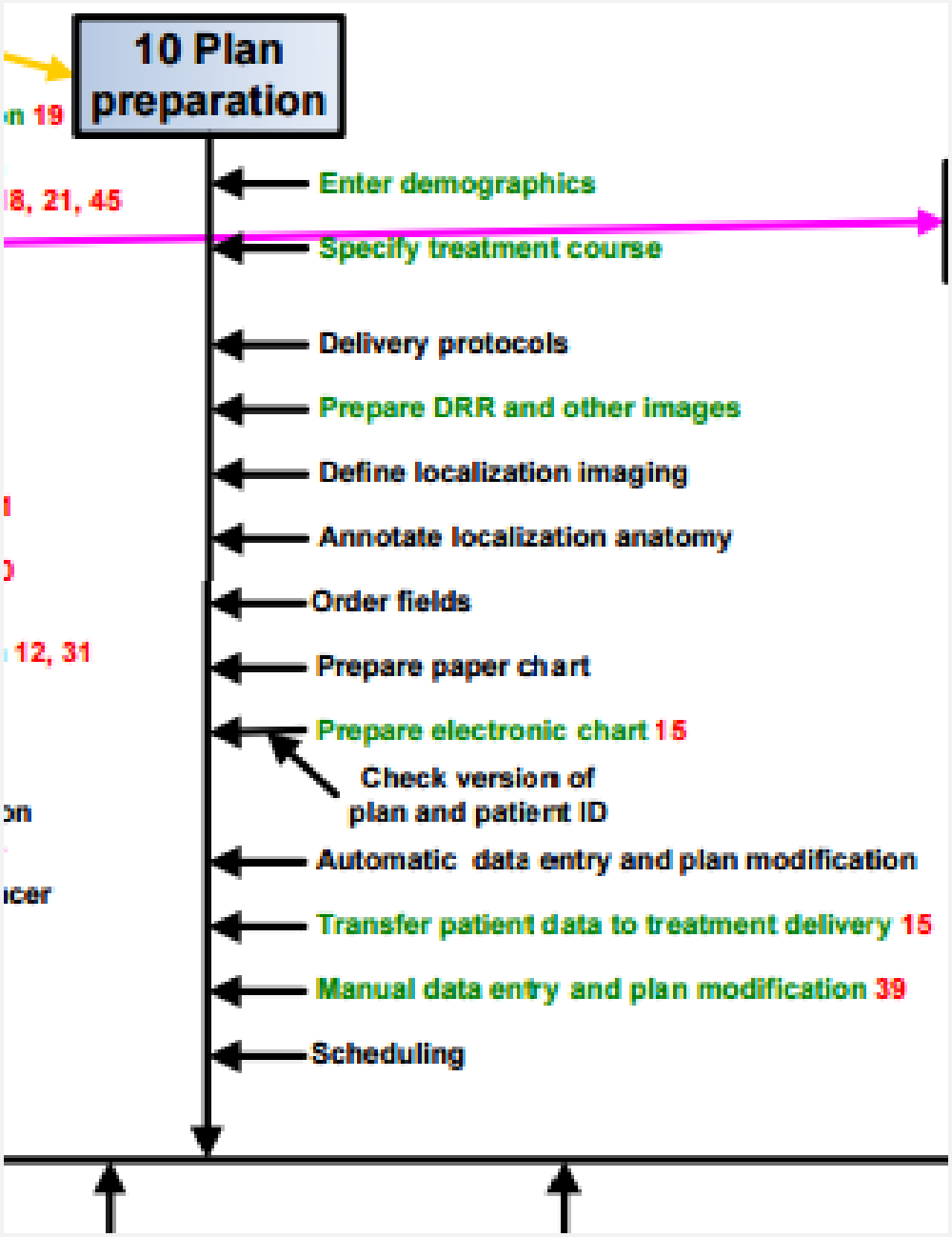
To Create Barriers, we use Process Maps



Process Map for IMRT

(TG 100 Example)




10 Plan preparation
Enter demographics
Specify treatment course
Delivery protocols
Prepare DRR and other images
Define localization imaging
Annotate localization anatomy
Order fields
Prepare paper chart
Prepare electronic chart 15
Check version of plan and patient ID
Automatic data entry and plan modification
Transfer patient data to treatment delivery 15
Manual data entry and plan modification 39
Scheduling

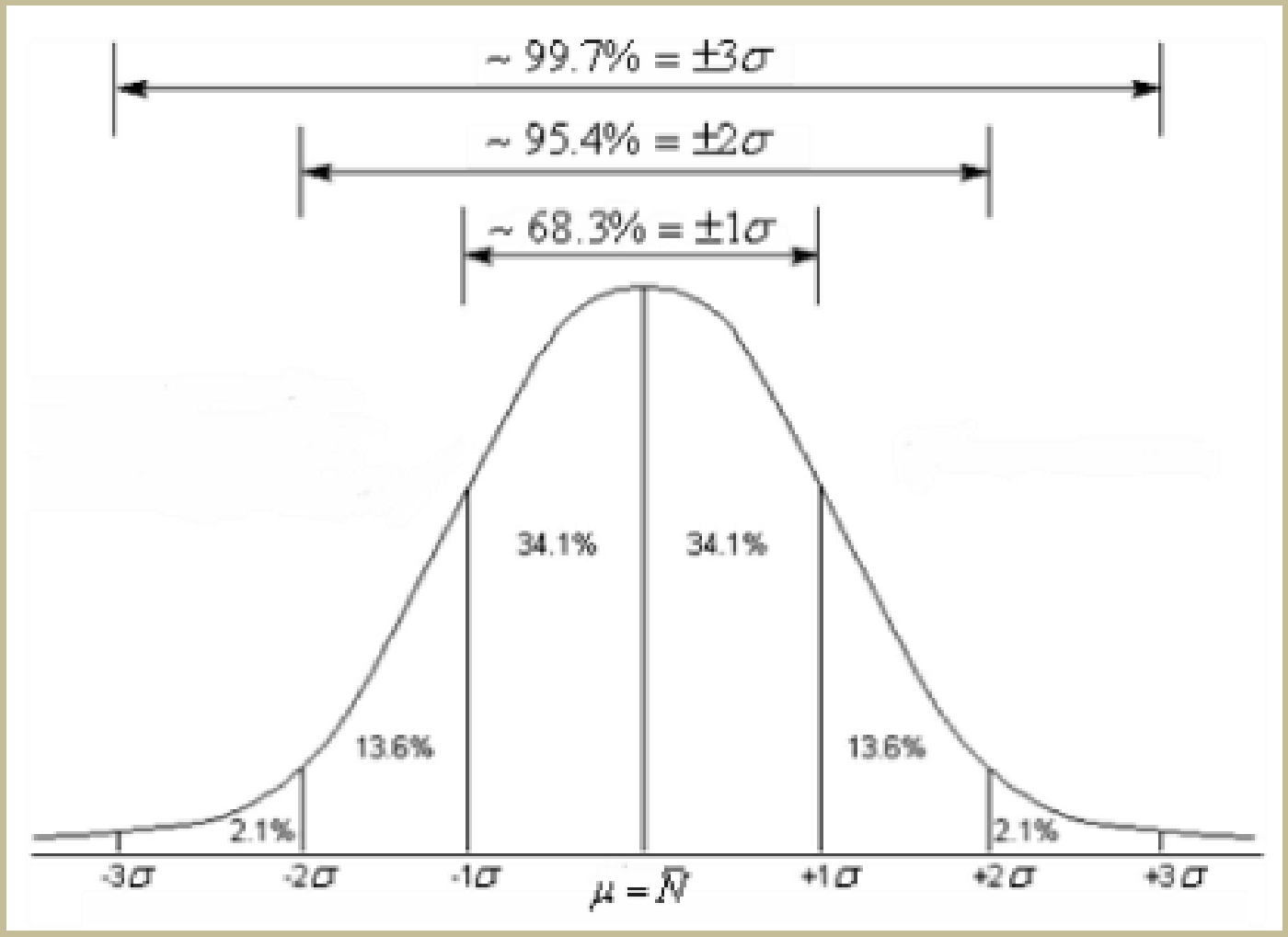
What is Safety ?

- The absence of an unacceptable risk of harm.
- What is harm in RT?
  - excess morbidity
  - sub-optimal tumour control.

Quality in Radiotherapy

The degree to which radiation therapy is consistent with current professional knowledge:

- **The prescription is appropriate, i.e. evidence based**
- **The prescription is delivered within tolerances determined by consensus in the profession**


~ 99.7% = ±3σ
~ 95.4% = ±2σ
~ 68.3% = ±1σ
34.1%
34.1%
13.6%
13.6%
2.1%
2.1%
-3σ
-2σ
-1σ
μ = N
+1σ
+2σ
+3σ

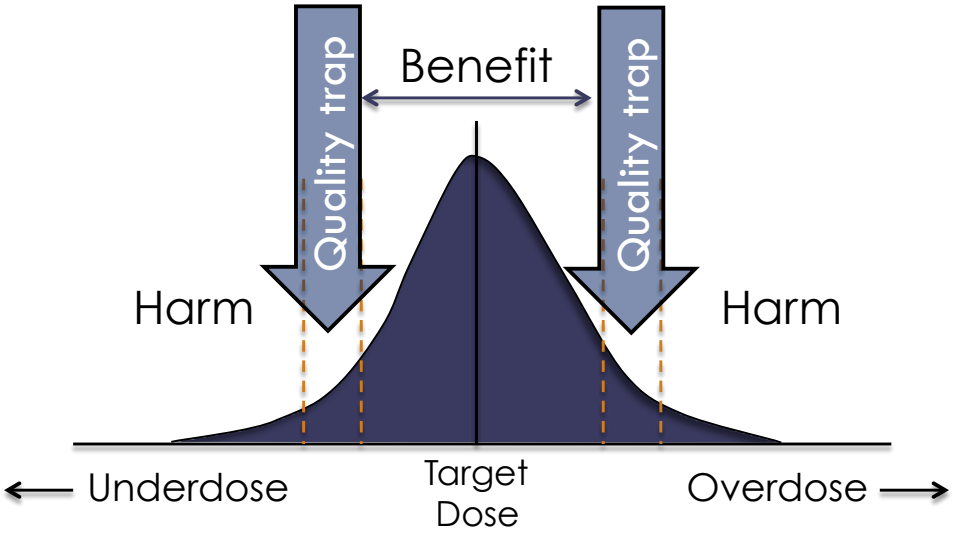
Is Safety an issue in Radiotherapy?

	"Serious" Incidents per course
New York State	0.012%
Varian	0.002%
UK	0.003%

The chance of dying or being injured on a U.S. domestic flight is about 0.00001% - Ford and Terezakis IJROBP 2010

How many patients fall into the "Quality Trap"?

There are about 750,000 patients receiving RT per year in the U.S.



At 0.01% that would be 75 serious accidents per year in the US alone!

If we ignore retreats, that is approximately 750,000 courses per year.

2.6% of 750,000 is about 20,000

Department of Radiation Oncology
TREATMENT VARIANCE REPORT

Reported on __/__/200_ Reported by:_____ Occurrence date(s): __/__/200_, _____
Patient ID:_____ Attending M.D.:_____Assigned Physicist:_____

Details: Blocks / MLC / MU / Wedges / Geometry / Energy / Mode / Setup / Machine_____/
Calculation / Plan / # of Fx's __ / Machine function / Identification
Other_____
Therapist(s): _____

Description of Variance (reporting staff):

_____
_____
_____
_____
_____
_____
_____
_____

Summary of Variance analysis (Physics) (report attached[ ])

_____
_____
_____
_____
_____

EFFECT CATEGORY	√	REPORTING CLASS	√
Prevented		Minor	
Corrected		Recordable	
Uncorrectable		Misadministration	

DEPARTMENTAL REVIEW: Date:__/__/200_
Comments:

_____

Corrective action:

_____
_____

Variance?

- A difference between what is expected and what actually occurs.
- An event that departs from the normal, the routine or from what we expected.

What information we collected?

Department of Radiation Oncology

TREATMENT VARIANCE REPORT

Reported on __/__/200_ Reported by:_____ Occurrence date(s): __/__/200_, _____

Patient ID:_____ Attending M.D.:_____Assigned Physicist:_____-

Details: Blocks / MLC / MU / Wedges / Geometry / Energy / Mode / Setup / Machine_____/

Calculation / Plan / # of Fx's __ / Machine function / Identification

Other_____

Therapist(s): _____ _____

Description of Variance (reporting staff):

_____

_____

_____

_____

_____

THE ABOVE SECTION TO BE COMPLETED BY REPORTER

What did we do with it?

- Bring to the attention of the attending Physician since s/he is ultimately responsible for the patient's treatment
- As the case may be, bring to the immediate attention of a supervisor or Physics.
- "Treatment Variance" forms are collected by Sherin

What did we do with the information?

- Analyze the specifics of the variance with three goals in mind
  - What is the effect on the patient
  - Is there a lesson to learn and changes to be made
  - What reporting category does the variance fall into.

Each case would be evaluated by the QA team, and the analysis reported

Summary of Variance analysis (Physics) (report attached[ ])

EFFECT CATEGORY	√	REPORTING CLASS	√
Prevented		Minor	
Corrected		Recordable	
Uncorrectable		Misadministration	

THE ABOVE SECTION TO BE COMPLETED BY PHYSICS

When evaluating the significance of an error, its effect has to be evaluated on the assumption that the patient's treatment will be solely determined by that particular error.

A measure, or action, is *truly redundant* if it can perform its function as if there was no other system or action in place.

Proposed Corrective Action and Discussion

- Let's change "xy"
- We should replace "yzz" with "rstuv"
- The last person to "zxttt" will do "abcd"
- We will never again "defgh"!

Monthly Presentation to the departmental QA Committee

OVERALL ANALYSIS:

Number of cases reviewed: _____fields _____ESTV 's

Number of cases identified: _____

Effect Category	#	Reporting Class	#
Prevented		Minor	
Corrected		Recordable	
Uncorrectable		Misadministration	

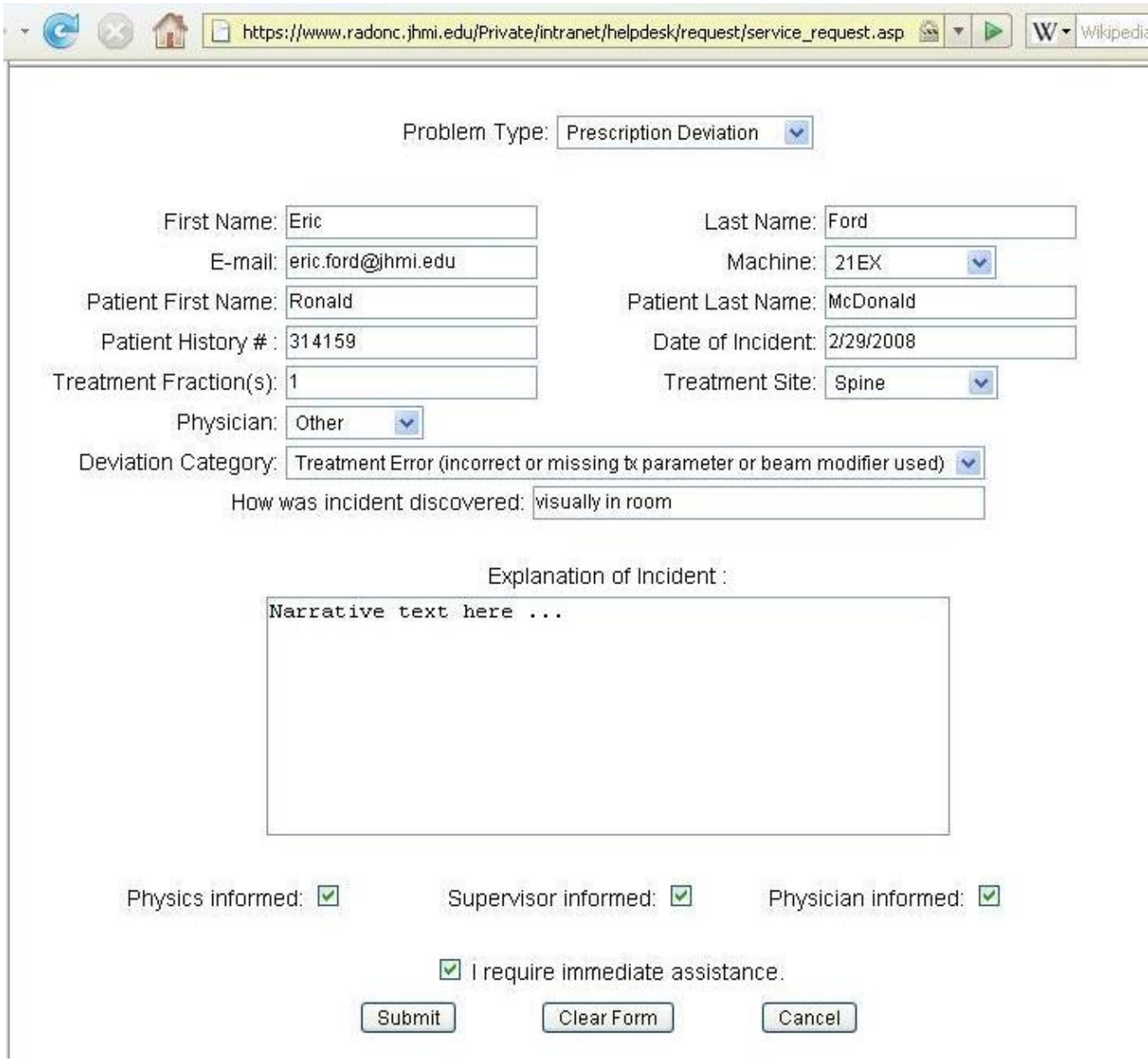
SPECIFIC CONCLUSION:

ACTION:

Newer incident reporting systems

- In-house web-based system available since 2007
- Includes near-misses
- 600 "minor incident" for every 1 "critical error"

(*Bird and Germain 1996)*



http://www.rosis.info/index.php

About ROSIS

ROSIS, an acronym for Radiation Oncology Safety Information System, is a patient safety tool specific to radiation oncology. It was established in 2001 under the auspices of the professional body "European Society of Therapeutic Radiology and Oncology" (ESTRO), and has successfully established an international voluntary incident and near incident reporting system, a supporting website and an annual teaching course on Patient Safety in Radiation Oncology.

http://www.rosis.info/

ROSIS
Radiation Oncology Safety Information System

DEPARTMENT REGISTRATION FORM

Radiation Oncology Safety Information System – a voluntary reporting system for radiation oncology

The first step in becoming an active ROSIS participant is registration.

This means that you must first complete and return this registration form giving details of your clinic and the local contact person/people who will be responsible for submitting reports. This will be the only time that you will be asked for this information.

General Information
Infrastructure(Equipment, etc)
QA procedures
Risk management (Reporting system, etc)

http://www.rosis.info/docs/Registration_Form_March_11.pdf

Incident ID	Date	Summary
1372689757	1-7-2013	being miss-ray treatment by not correct adjusted target volume
1366098290	16-4-2013	High density materials in IGRT carbon fiber tabletop interface to the head and neck Posifix extension.
1347270437	10-9-2012	Pt was scheduled for IMRT treatment 25 x 2 Gy. The IMRT planning was accidently done with a number of fractionations of 16 (as is also often used for treatment of the breast; 16 x 2.66Gy). The planning objectives was 50Gy in the PTV, as intended. Thus, 50 Gy was planned in 16 fractions instead of 25, resulting in a fraction dose of approx 3.13 Gy. The plan (field sizes, MU etc) was sent to the R&V system, but not the number of fractions. This is not possible with the current configuration of the R&V system. The fields were checked but the discrepancy between planned and intended number of fractions was not noted. The patient received 25 x 3.13 Gy = approx 78.25 Gy instead of 50Gy. The patient also received a boost (planned 8 x 2Gy). Due to severe skin reaction the treatment was checked and the error found. The last fraction of the boost was omitted.
1343040776	23-7-2012	Wrong treatment couch height selected due (SSD too large) to unusual treatment technique/geometry. Thoracic wall irradiation was interpreted as mamma irradiation.

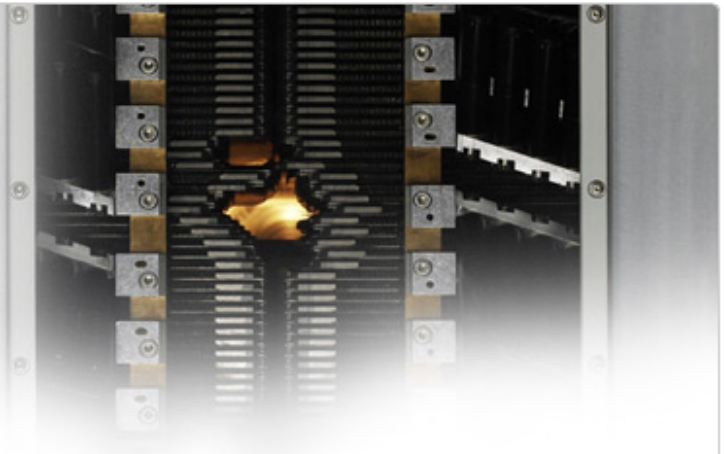
http://www.rosis.info/docs/Registration_Form_March_11.pdf

IAEA | SAFRON - Safety in Radiation Oncology

Dataset: All incident reports

Safety Reporting and Learning System for Radiotherapy

SAFRON is voluntary and aims to enable global shared learning from safety related events and safety analysis in order to improve the safe planning and delivery of radiotherapy. SAFRON is provided by the IAEA.



Actions

- **Browse Safety Info by Process Step >**
- Search for Incident Reports >
- Search for Documents & Links >
- Request Registration >
- View Instructions >

Featured Incident Reports

Plan with two isocenters, patient is not repositioned in between

Craniospinal irradiation with three isocenters. Spinal field had two isocenters. Patient was not repositioned for one fraction and part of the upper spine got 100% higher dose than intended and lower...

Isocentre Co-ordinates in Mosaiq incorrect, and first

Featured Documents & Links

Quantitative cone-beam CT imaging in radiation therapy using planning CT as a prior: first patient

This study looked at the difficulties of using CBCT for patient positioning because of poor imaging and scatter contamination. By using a correction method using the planning CT the capabilities of...

Automatic patient alignment system using 3D

SAFRON

Information and Instructions for Registering with NUCLEUS

Prior to registering with Safety Reporting and Learning System for Radiotherapy (SAFRON), the registrant must register with NUCLEUS, the Agency's information resource catalogue. The link to NUCLEUS is: http://nucleus.iaea.org/Home/index.html

Instructions for Registering with SAFRON

SAFRON is an integrated voluntary reporting registry of radiation oncology incidents and near misses. Its success is dependent on facilities registering and sharing incidents that occur in their institutions. The registration form includes details on the equipment, staff and environment in your centre. This information indicates the complexity of the processes within departments. It will be used to carry out trend analyses of incidents in relation to complexity of practice, working environment and educational background of professional staff in a range of clinic types. The information will not be seen by other users of SAFRON.

https://rpop.iaea.org/SAFRON/StaticContent/safron-instructions.pdf

- 1. Non-clinical phase
- 2. Pre-treatment phase
- 3. Treatment phase
  - 3.1. Treatment setup
    - 3.1.1. Patient setup
      - 3.1.1.1. Patient ID process
      - 3.1.1.2. Patient data ID process
      - 3.1.1.3. Explanation/instructions to patient
      - 3.1.1.4. Patient positioning
      - 3.1.1.5. Use of reference marks
      - 3.1.1.6. Other
    - 3.1.2. Treatment unit setup
      - 3.1.2.1. Setting of treatment machine parameters
      - 3.1.2.2. Setting of collimator angle
      - 3.1.2.3. Setting of jaw position

*Number of staff:

*Radiation oncologists (physicians):

*Medical physicists:

*Radiation Therapy Technologists (RTT) / Radiation Therapists / Staff at treatment units treating patients:

*Radiation Therapy Technologists (RTT) / Radiation Therapists / Staff at simulator and/or in-house CT:

*Staff doing dosimetry i.e. treatment planning etc:

*Staff doing technical maintenance on radiotherapy equipment:

*How is most of your equipment maintenance performed?

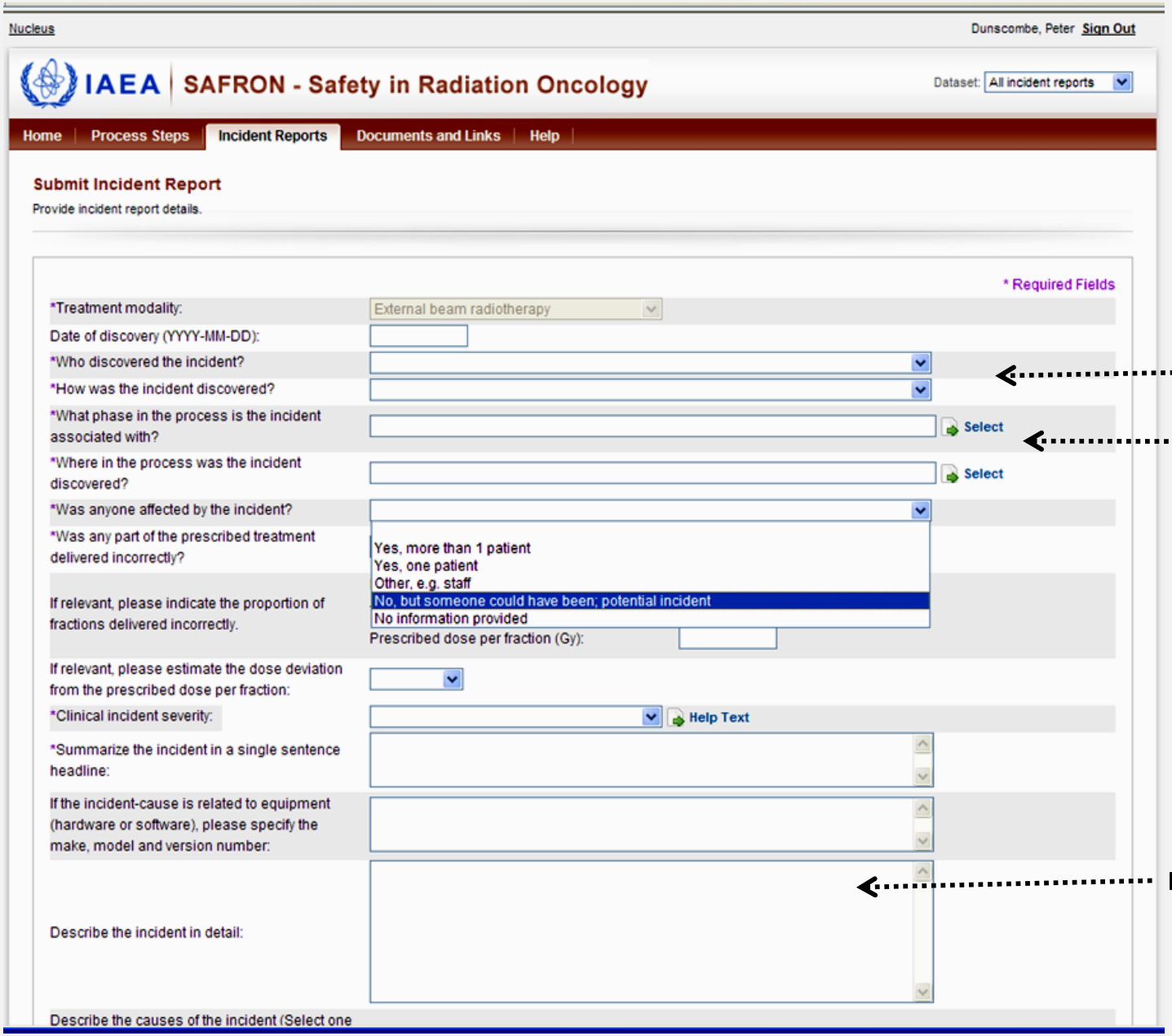
Safety infrastructure in place at the clinic:
(Select all that apply to your clinic)

- There are documented policies and procedures for most of the clinical processes
- There are written policies and procedures for equipment quality control (including software)
- There are appropriate education and training for staff
- There is a committe with responsibility for on-going quality and safety improvement

Safety barriers in place at the clinic:
(Select all that apply to your clinic)

- Verification of patient ID
- Verification that pretreatment condition have been taken into account
- Verification of imaging data for planning (CT scan, fusion, imaging modality, correct data set)
- Verification reference points
- Physician peer review
- Review of treatment plan
- Independent confirmation of dose
- Time out
- Use of record and verifying system
- Verification of treatment accessories
- Image based position verification
- In vivo dosimetry

https://rpop.iaea.org/SAFRON/ClinicRegistration/ClinicRegistrationEdit.aspx



Option Menus

Tables

Free text description

https://rpop.iaea.org/RPOP/RPoP/Modules/login/safron-register.htm

ASTRO and the AAPM (2014) - medical specialty society sponsored radiation oncology PSO.

Goal: Educate the radiation oncology community on how to improve safety and patient care.

ASTRO and the AAPM (2014) - medical specialty society sponsored radiation oncology PSO.

Goal: Educate the radiation oncology community on how to improve safety and patient care.

What to Report or Track

- Explicit events – frequent events
- Random events
- Actual errors
- Potential errors (near misses)
- Corrective measures

Incident Reporting Depends on Factors

- Culture
- Reporting system and guidelines
- Competence to interpret reported data
- Willingness to implement
  - Changes based on collected data and analyses
- Ability to share data and provide feedback
  - Power distance index

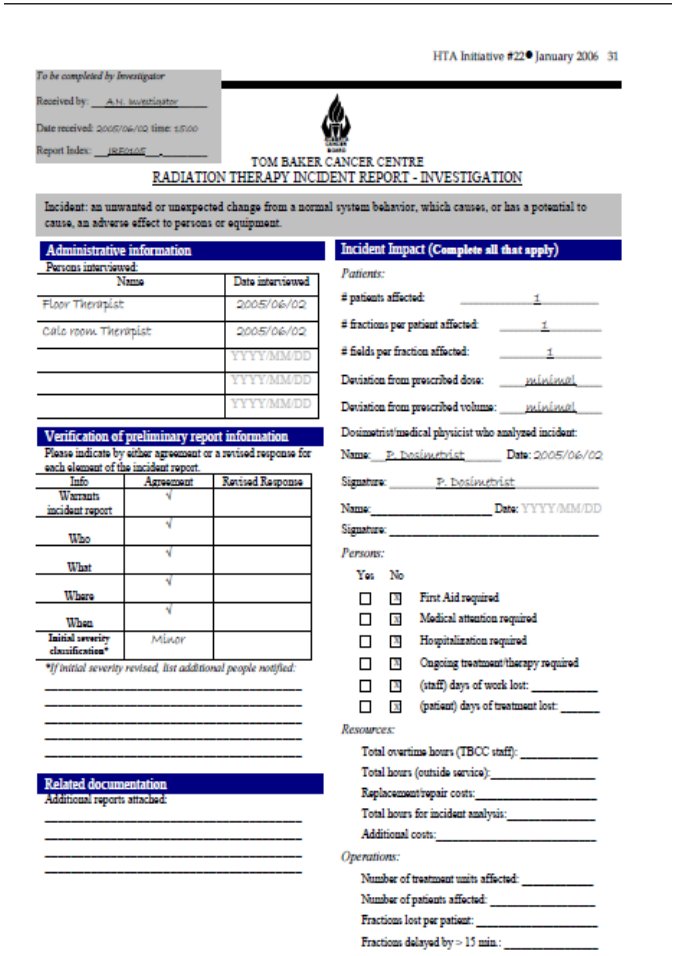
Organizational Culture

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

Reason, J., Managing the risks of organizational accidents. Different organizational cultures

Final Disposition

- Resolution and corrective action
- Responsible person
- Implementation plan
- Evaluation plan
- Follow up plan



HTA Initiative #22 • January 2006 31

To be completed by Investigator
Received by: A.N. Investigator
Date received: 2005/06/02 time: 15:00
Report Index: IRE0105

TOM BAKER CANCER CENTRE
RADIATION THERAPY INCIDENT REPORT - INVESTIGATION

Incident: an unwanted or unexpected change from a normal system behavior, which causes, or has a potential to cause, an adverse effect to persons or equipment.

Administrative information

Persons interviewed:

Name	Date interviewed
Floor Therapist	2005/06/02
Cala room Therapist	2005/06/02
	YYYY/MM/DD
	YYYY/MM/DD
	YYYY/MM/DD

Verification of preliminary report information

Please indicate by either agreement or a revised response for each element of the incident report.

Info	Agreement	Revised Response
Warrants incident report	√	
Who	√	
What	√	
Where	√	
When	√	
Initial severity classification*	Minor	

**If initial severity revised, list additional people notified:*

Related documentation

Additional reports attached:

Incident Impact (Complete all that apply)

Patients:

patients affected: 1
fractions per patient affected: 1
fields per fraction affected: 1
Deviation from prescribed dose: minimal
Deviation from prescribed volume: minimal

Dosimetrist/medical physicist who analysed incident:
Name: P. Dosimetrist Date: 2005/06/02
Signature: P. Dosimetrist
Name: Date: YYYY/MM/DD
Signature:

Persons:

Yes	No	
☐	☒	First Aid required
☐	☒	Medical attention required
☐	☒	Hospitalization required
☐	☒	Ongoing treatment/therapy required
☐	☒	(staff) days of work lost:
☐	☒	(patient) days of treatment lost:

Resources:

Total overtime hours (TBCC staff):
Total hours (outside service):
Replacement/repair costs:
Total hours for incident analysis:
Additional costs:

Operations:

Number of treatment units affected:
Number of patients affected:
Fractions lost per patient:
Fractions delayed by > 15 min.:

Root Cause Analysis - when

1. Any single obviously serious event
2. Systematic events
3. High frequency sporadic events

Root Cause Analysis - how

1. Collect information – WHAT happened
2. Identify causes – WHY, WHY, WHY, WHY, WHY
3. Recommendations for remediation
4. Implement and Monitor

Incident Reporting and Learning systems must be:

Friendly for reporting
Responsive
Dynamic

Safety culture – free of fear

MANY TOOLS!!

Safety culture – free of fear

Incident Learning systems-
Friendly for reporting, responsive and dynamic

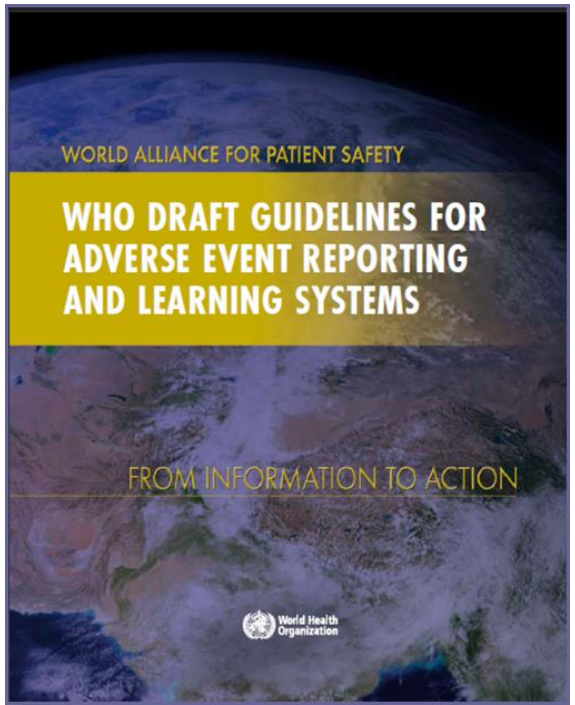
Root cause analysis methods

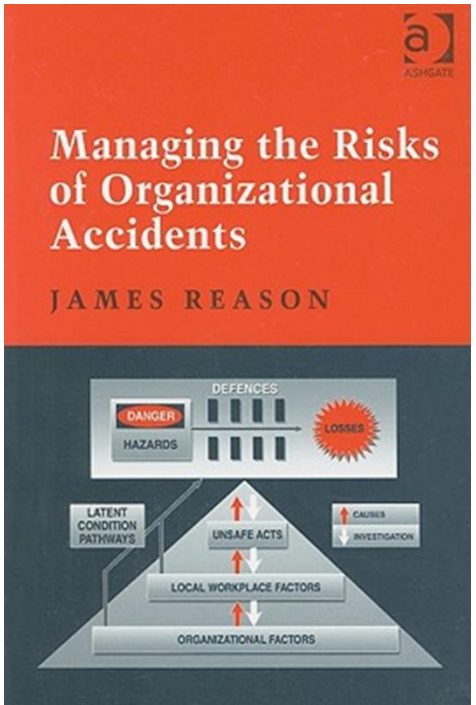
Check lists

Standard procedures and handoffs

Resources

- IAEA -> http://www.iaea.org/
- Lessons learned from accidents in radiotherapy, Safety Reports Series No. 17, IAEA, Vienna (2000).
- ICRP-> Prevention of accidental exposures to patients undergoing radiation therapy. Publication 86, Volume 30 No.3 (2000)
- AAPM - > http://www.aapm.org/
- ASTRO -> https://www.astro.org/
- TreatSafely -> http://www.treatsafely.org/index.php
- AHRQ (Agency for Healthcare Research and Quality)
  - http://www.ahrq.gov/patients-consumers/care-planning/errors/index.html





References

ASTRO report 2012

Safety is No Accident: A Framework for Quality Radiation Oncology and Care. Zeitman A, Palta J, Steinberg M. ASTRO; 2012

AAPM white-paper 2012

Consensus recommendations for incident learning database structures in radiation oncology. Ford EC, Fong de Los Santos L, Pawlicki T, Sutlief S, Dunscombe P. Med Phys. 2012;39(12):7272-90.

ASTRO safety white-papers

Safety considerations for IMRT: Executive summary. Moran JM, Dempsey M, Eisbruch A, Fraass BA, Galvin JM, Ibbott GS, et al. Pract Radiat Oncol. 2011;1(3):190-5.

Assuring safety and quality in image-guided delivery of radiation therapy. Jaffray D, Langen KM, Mageras G, Dawson L, Yan D, Adams R, et al. Pract Radiat Oncol. 2013;in press.

ASRT safety white-paper

Radiation Therapy Safety: The Critical Role of the Radiation Therapist. Odle, T, Rosier, N. ASRT Education and Research Fnd. 2012.

The art of learning from our mistakes

Contact: ypipman@yahoo.com