Treatment Plan Checks as a Risk Management Tool

Tomas Kron
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Acknowledgements: Keith Offer, Chris Fox, Lotte Fog and many others

Presented Platform : **Global Alliance for Medical Physics Education and Research (GAMPER)**

8 July 2025

Peter MacCallum Cancer Centre, Melbourne

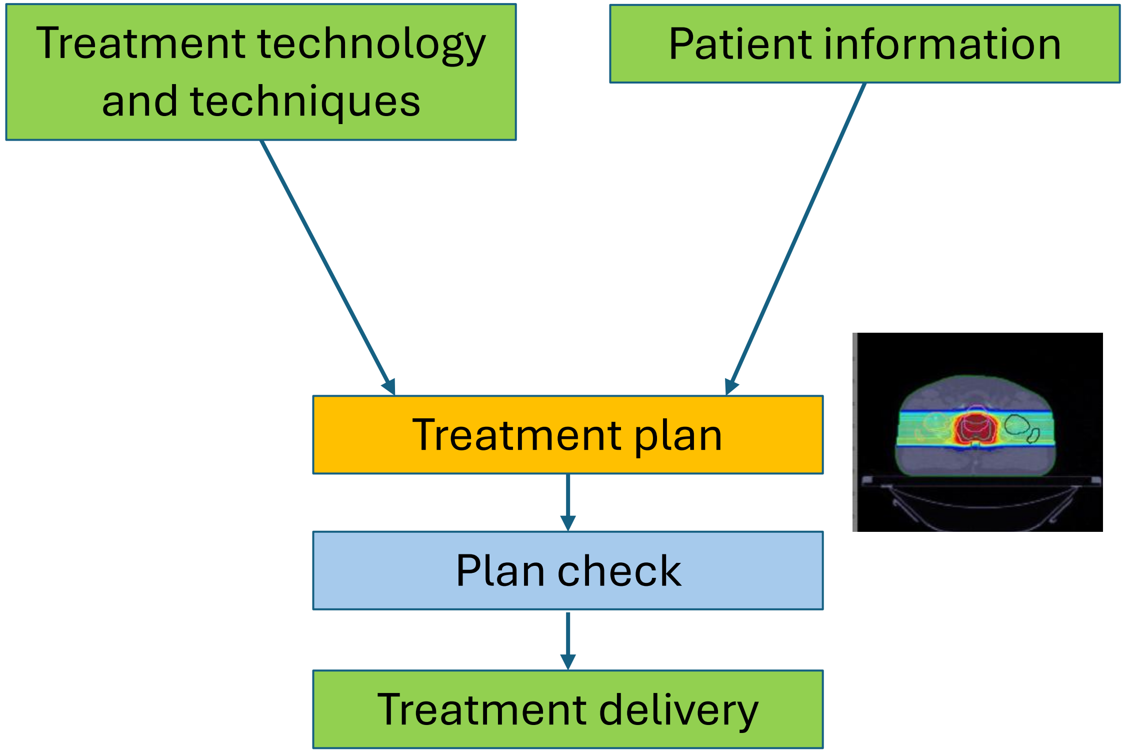
- 5 campuses
- 16 linacs, 1 GammaKnife, 4 SXR
- 7 CT, 1 PET/CT
- HDR, LDR and eBrachytherapy
- SRS, SBRT, TBI, TSET, intraoperative
- More than 7000 RT patients per year
- Varian Eclipse in the cloud (+ Brainlab Elements, Gammaplan, Oncentra brachy)
- MOSAIQ ROIS
- Physical Sciences includes engineering and imaging
- Organisation in tumour streams

- COI Research collaborations with Varian Medical Systems, Vison RT and RefleXion

Main campus Melbourne

Radiotherapy treatment plan

- Personalised
- Optimised
- The ultimate documentation of radiotherapy intend and approach
- Requires checks



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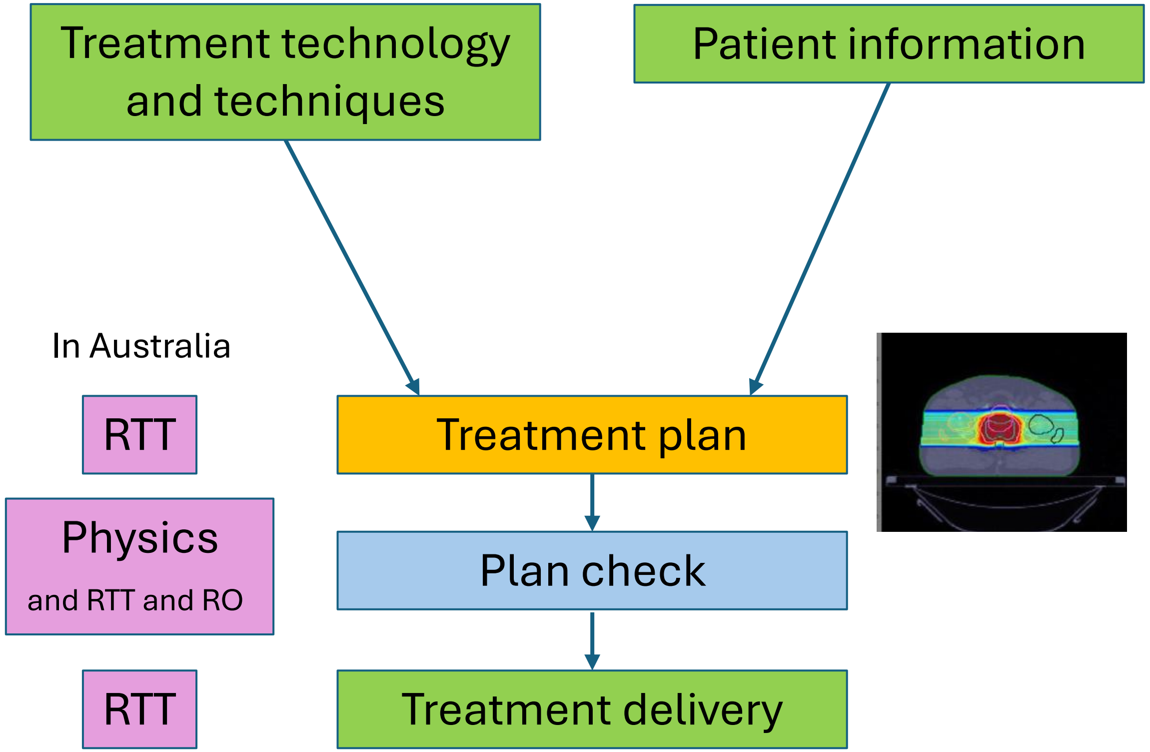
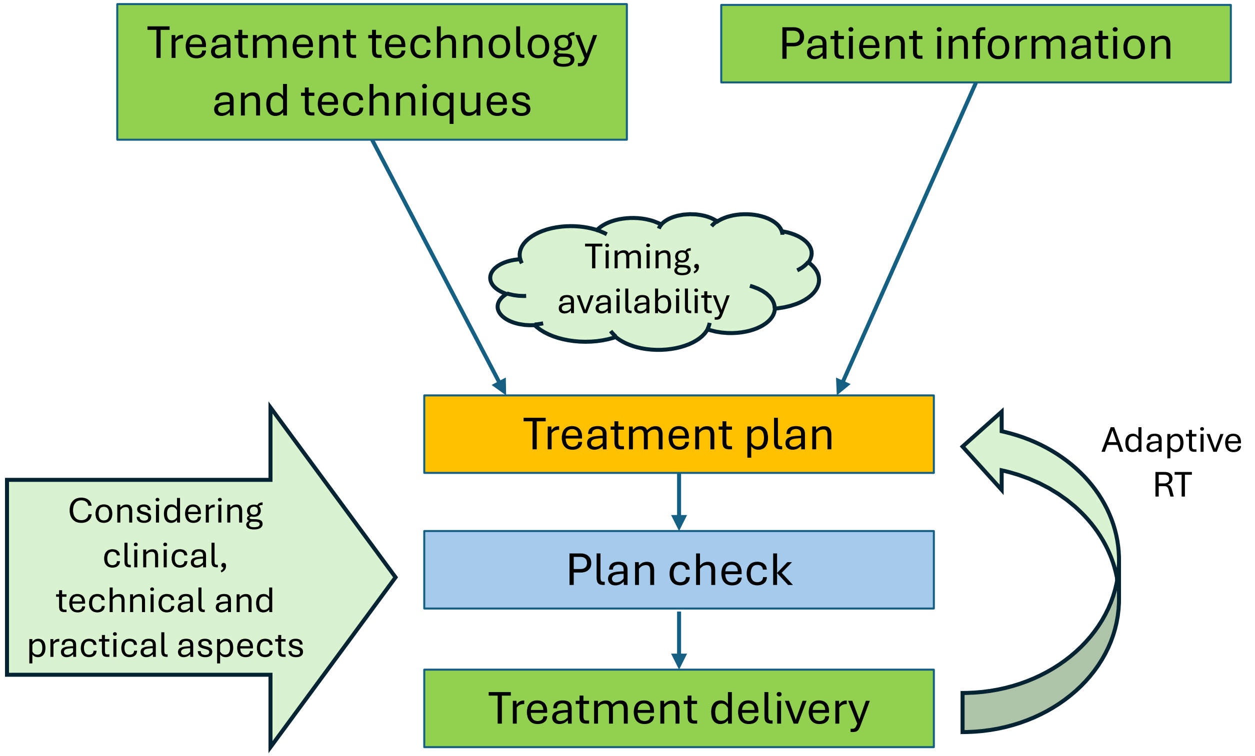


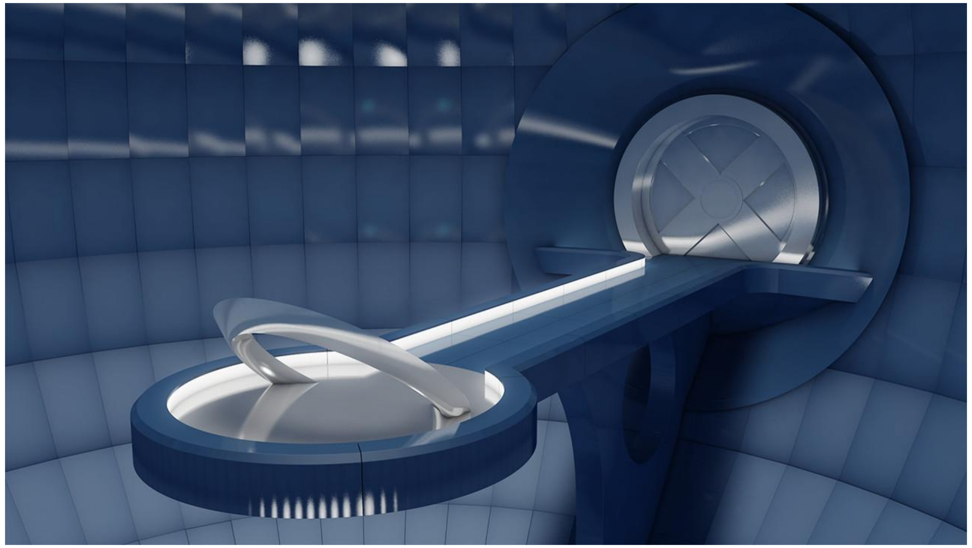
Radiotherapy treatment plan

- Personalised
- Optimised
- The ultimate documentation of radiotherapy intend and approach
- Requires checks
- Multidisciplinary
- May be repeated



Objectives of the presentation

- Provide background for physics plan checks
- Explore where plan checks fit into a radiotherapy workflow
- Analyse risks and benefits associated with plan checks
- Not make recommendations for your environment – it is something every physicist must do for their environment



Physical and Engineering Sciences in Medicine (2024) 47:7–15
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ACPSEM POSITION PAPER

ACPSEM position paper: pre-treatment patient specific plan checks and quality assurance in radiation oncology

Lotte S. Fog[1] · Luke K. Webb[2] · Jeffrey Barber[3] · Matthew Jennings[4] · Sam Towns[1] · Susana Olivera[5] · John Shakeshaft[6] · On behalf of the ACPSEM Radiation Oncology Specialty Group (ROSG)

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Abstract

The Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM) has not previously made recommendations outlining the requirements for physics plan checks in Australia and New Zealand. A recent workforce modelling exercise, undertaken by the ACPSEM, revealed that the workload of a clinical radiation oncology medical physicist can comprise of up to 50% patient specific quality assurance activities. Therefore, in 2022 the ACPSEM Radiation Oncology Specialty Group (ROSG) set up a working group to address this issue. This position paper authored by ROSG endorses the recommendations of the American Association of Physicists in Medicine (AAPM) Task Group 218, 219 and 275 reports with some contextualisation for the Australia and New Zealand settings. A few recommendations from other sources are also endorsed to complete the position.

Keywords Quality assurance · Plan check · Position paper

Physical and Engineering Sciences in Medicine (2024) 47:7–15
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ACPSEM POSITION PAPER

ACPSEM position paper: pre-treatment patient sp... and quality assurance in radiation oncology

...y Barber[3] · Matthew Jennings[4] · Sar...
...CPSEM Radiation Oncology Speciali...

Keywords Quality assurance · Plan chec...

Tolerance limits and methodologies for IMRT measurement-based verification QA: *Recommendations of AAPM Task Group No. 218*

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Purpose: Patient-specific IMRT QA measurements are important components of processes designed to identify discrepancies between calculated and delivered radiation doses. Discrepancy tolerance limits are neither well defined nor consistently applied across centers. The AAPM TG-218 report provides a comprehensive review aimed at improving the understanding and consistency of these processes as well as recommendations for methodologies and tolerance limits in patient-specific IMRT QA.
Methods: The performance of the dose difference/distance-to-agreement (DTA) and γ dose distribution comparison metrics are investigated. Measurement methods are reviewed and followed by a discussion of the pros and cons of each. Methodologies for absolute dose verification are discussed and new IMRT QA verification tools are presented. Literature on the expected or achievable agreement between measurements and calculations for different types of planning and delivery systems are reviewed and analyzed. Tests of vendor implementations of the γ verification algorithm employing benchmark cases are presented.
Results: Operational shortcomings that can reduce the γ tool accuracy and subsequent effectiveness for IMRT QA are described. Practical considerations including spatial resolution, normalization, dose threshold, and data interpretation are discussed. Published data on IMRT QA and the clinical experience of the group members are used to develop guidelines and recommendations on tolerance and action limits for IMRT QA. Steps to check failed IMRT QA plans are outlined.
Conclusion: Recommendations on delivery methods, data interpretation, dose normalization, the use of γ analysis routines and choice of tolerance limits for IMRT QA are made with focus on detecting differences between calculated and measured doses via the use of robust analysis methods and an

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AAPM SCIENTIFIC REPORT
MEDICAL PH...

Report of AAPM Task Group 219 on independent calculation-based dose/MU verification for IMRT

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Abstract
Independent verification of the dose per monitor unit (MU) to deliver... dose to a patient has been a mainstay of radiation oncology qu... (QA). We discuss the role of secondary dose/MU calculation pro... of a comprehensive QA program. This report provides guidelines... based dose/MU verification for intensity modulated radiation the... volumetric modulated arc therapy (VMAT) provided by various modalities. We provide a review of various algorithms for "independent/second check" of monitor unit calculations for IMRT/VMAT. The report makes recommendations on the clinical implementation of secondary dose/MU calculation programs; on commissioning and acceptance of various commercially available secondary dose/MU calculation programs; on benchmark QA and periodic QA; and on clinically reasonable action levels for agreement of secondary dose/MU calculation programs.

Strategies for effective physics plan and chart review in radiation therapy: Report of AAPM Task Group 275

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Background: While the review of radiotherapy treatment plans and charts by a medical physicist is a key component of safe, high-quality care, very few specific recommendations currently exist for this task.
Aims: The goal of TG-275 is to provide practical, evidence-based recommendations on physics plan and chart review for radiation therapy. While this report is aimed mainly at medical physicists, others may benefit including dosimetrists, radiation therapists, physicians and other professionals interested in quality management.
Methods: The scope of the report includes photon/electron external beam radiotherapy (EBRT), proton radiotherapy, as well as high-dose rate (HDR) brachytherapy for gynecological applications (currently the highest volume brachytherapy service in most practices). The following review time points are considered: initial review prior to treatment, weekly review, and end-of-treatment review. The Task Group takes a risk-informed approach to developing recommendations. A failure mode and effects analysis was performed to determine the highest-risk aspects of each process. In the case of photon/electron EBRT, a survey of all American Association of Physicists in Medicine (AAPM) members was also conducted to determine current practices. A draft of this report was provided to the full AAPM membership for comment through a 3-week open-comment period, and the report was revised in response to these comments.

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AAPM REPORTS & DOCUMENTS
JOURNAL OF APPLIED CLINICAL MEDICAL PHYSICS

Medical Physics Practice Guideline (MPPG) 11.a: Plan and chart review in external beam radiotherapy and brachytherapy

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Abstract
A therapeutic medical physicist is responsible for reviewing radiation therapy treatment plans and patient charts, including initial treatment plans and new chart review, on treatment chart (weekly) review, and end of treatment chart review for both external beam radiation and brachytherapy. Task group report TG 275 examined this topic using a risk-based approach to provide a thorough analysis and guidance for best practice. Considering differences in resources and workflows of various clinical practice settings, the Professional Council of the American Association of Physicists in Medicine assembled this task group to develop a practice guideline on the same topic to provide a minimum standard that balances an appropriate level of safety and resource utilization. This medical physics practice guidelines (MPPG) thus provides a concise set of recommendations for medical physicists and other clinical staff regarding the review of treatment plans and patient charts while providing specific recommendations about who to be involved, and when/what to check in the chart review process. The recommendations, particularly those related to the initial plan review process, are critical for preventing errors and ensuring smooth clinical workflow. We believe that an effective review process for high-risk items should include multiple layers with collective efforts across the department. Therefore, in this report, we make specific recommendations for various roles beyond medical physicists. The recommendations of this MPPG have been reviewed and endorsed by the American Society of Radiologic Technologists and the American Association of Medical Dosimetrists.

KEYWORDS
MPPG 11.a, plan and chart review, safety and quality

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ELSEVIER

Radiotherapy and Oncology 42 (1997) 297–301

Major errors (>5%) picked up by physicists checking treatment sheets (category (c))

Age and sex	Radical or palliative	Prescribed dose	Treatment site	Treatment details	Errors	Magnitude of error (%)	Detectable by in vivo dosimetry?
39 F	Radical	20 Gy in 10 fractions	Thyroid eye disease, both orbits	Two opposed, half-blocked, 6 MV beams	Incorrect area factors and TARs	−15 (underdosage)	Yes
72 F	Radical	50 Gy in 20 fractions	Recurrent BCC of nose	AP 9 MeV electron beam; bolus	Omitted applicator factor	+10 (overdosage)	Yes
64 M	Radical	50 Gy in 20 fractions	BCC of nose	LAO 6 MeV electron beam; bolus	Incorrect cutout factor and omitted ISL correction	+13 (overdosage)	Yes
58 F	Radical	50 Gy in 25 fractions	SCC in axilla; supraclavicular region	AP-PA 6 MV beams	Irregular field size program not used for shielded fields	−7 (underdosage)	No
77 M	Adjuvant post-operative	45 Gy in 25 fractions	Ca rectum (Dukes C)	Four field AP-PA/laterals 6 MV photon beams	Incorrect normalisation percentage	+8 (overdosage)	Yes
73 M	Radical	45 Gy in 23 fractions	Ca oesophagus; mediastinum and supraclavicular fossa	Four field AP-PA/laterals 6 MV photon beams	Incorrect TARs	−12 (underdosage)	Yes

An independent check of treatment plan, prescription and dose calculation as a QA procedure

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Received 11 March 1996; revised version received 17 December 1996; accepted 31 December 1996

Abstract

In many radiotherapy centres where planning for external beam treatments is performed by radiation therapists, the treatment sheet and its calculations are independently checked by staff from a different educational background, typically a radiotherapy physicist. The benefits of this practice were evaluated in a radiotherapy department with two linear accelerators, one combined superficial-orthovoltage unit and one telecaesium unit. Within the 19 months of the investigation period, 2328 checks were performed on the treatment sheets of 1579 patients. In six cases, errors in excess of 5% were detected, which if uncorrected, could potentially have affected local tumour control or caused normal tissue complications. It was found that an independent check of treatment sheets assists in keeping these errors as low as can be achievable in clinical practice, and suggests that treatment sheet checking and in vivo dosimetry play a complementary role in this aim. Independent treatment sheet checking is an important quality assurance (QA) activity, with additional advantages such as improved communication in the department, education of staff and in vivo dosimetry targeting. Therefore the advantages of the procedure seem to outweigh the additional workload of approximately 0.3 full-time staff per 1000 patients per year. © 1997 Elsevier Science Ireland Ltd.

Nearly 30 years ago:

- Newcastle Mater Hospital, 3 linacs
- Analysed 2328 checks over 19 months
  - Minor (<1%)
  - Action
  - Major (>5%)
- About 10% of plans warranted intervention
- Six major (> 5%) errors

Australasian Physical & Engineering
Sciences in Medicine (1996) Vol. 19 No.2

RADIOTHERAPY TREATMENT CHECKING PROCEDURES THROUGHOUT AUSTRALASIA : RESULTS OF A SURVEY

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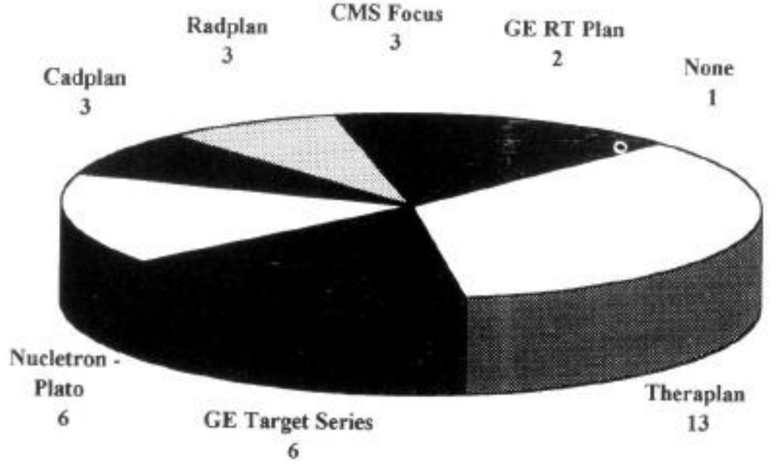

Figure 3. *Planning computers used in Australasian Radiation Oncology departments. Multiple nominations possible.*

1995: 37 hospitals in Australia and NZ

Extent of Checking at Centre	Number of Centres	% of Total Centres	Planning Computer MU** Calculation	Computer MU** Check	Both	Reverse Check
All	7(30)	23%	0(7)	2(7)	0(7)	1 (7)
Selection - Major	3 (30)	10%	2 (3)	0 (3)	0 (3)	0 (3)
Selection-Minor	11(30)	37%	3 (11)	3 (11)	5 (11)	2 (11)
None	6 (30)	20%	1(6)	1(6)	0 (6)	1(6)
Other*	3 (30)	10%				

Table 2. *The role of computers in the checking of treatment sheets and the relationship of the extent of this role to the checking load of the radiotherapy department.*
*The data is organised to look more at individual physics groups' procedures more than individual centres. Four centres are looked after by the one physics group**. *Note MU*** *= monitor units.*

20% no checks

Australasian Physical & Engineering Sciences in Medicine (1996) Vol. 19 No.2

RADIOTHERAPY TREATMENT CHECKING PROCEDURES THROU AUSTRALASIA : RESULTS OF A SU

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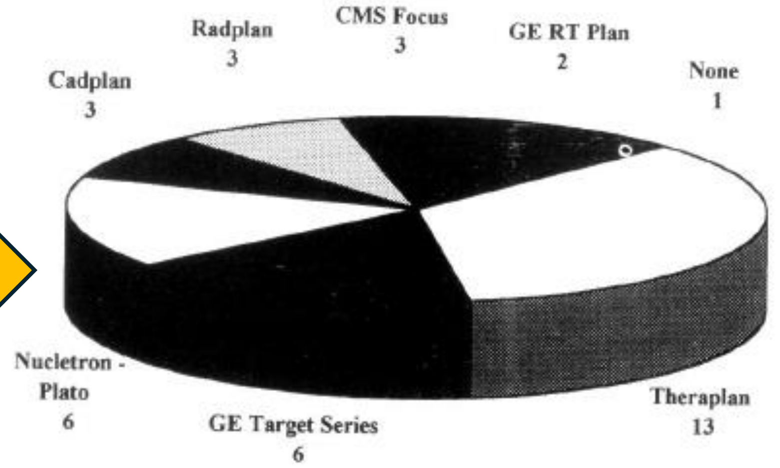
Multivendor departments



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This would characterise our present practice (stereo, IMRT, new Tx,...)
2017: 35%
2025: >70%

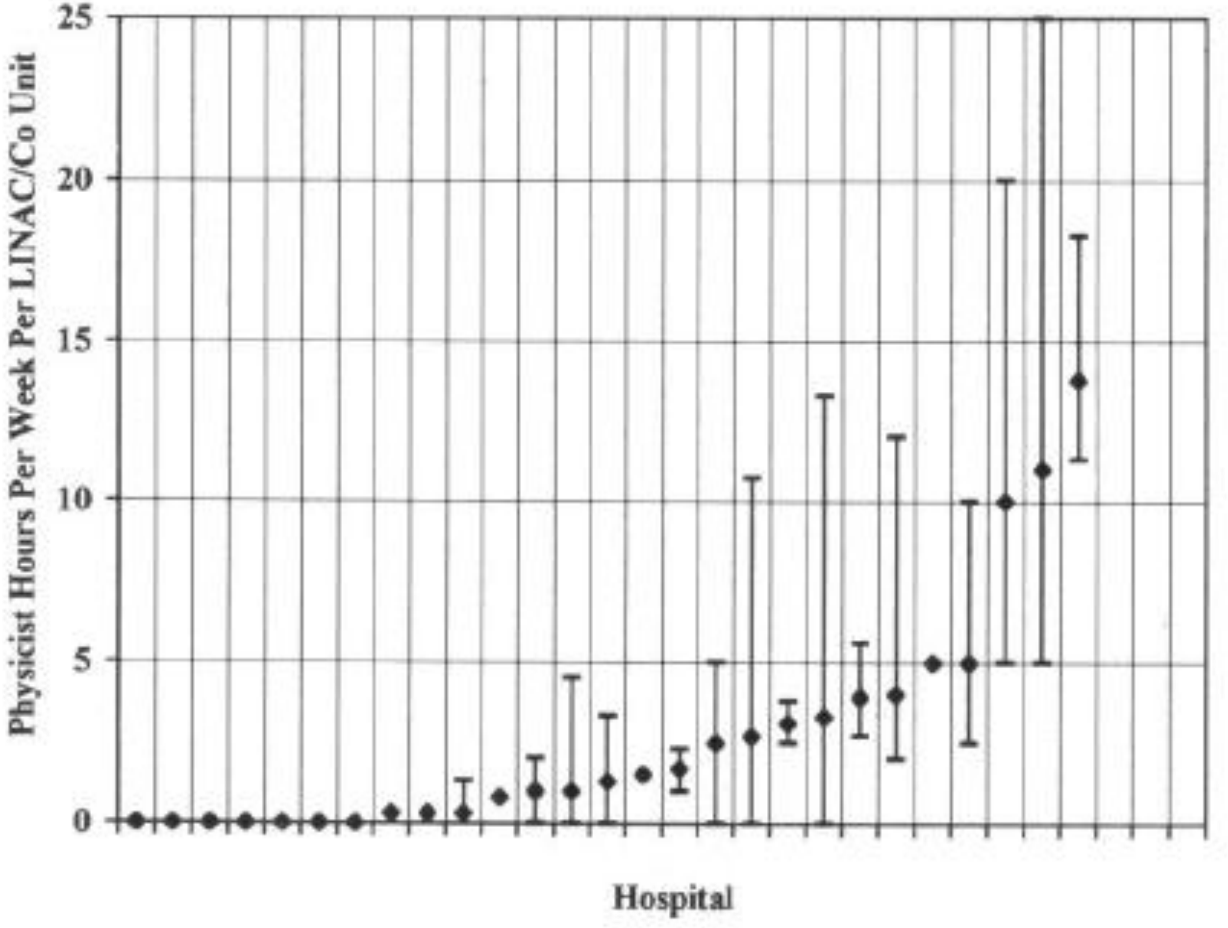
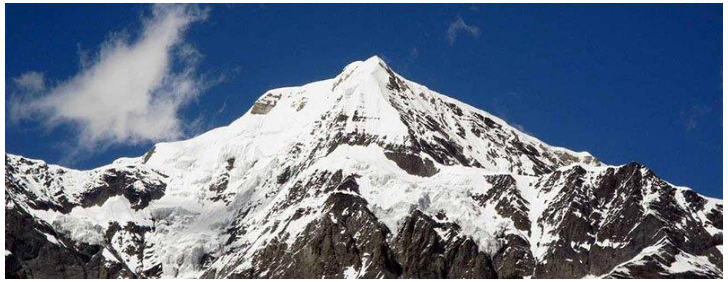


Figure 5. *Time spent checking treatment sheets per week per machine (LINAC or Cobalt Unit). Data is normalised to give an indication of the checking workload, independent of department size. Note that often a few physicists share the checking workload*

Physics workload for checking (1995)

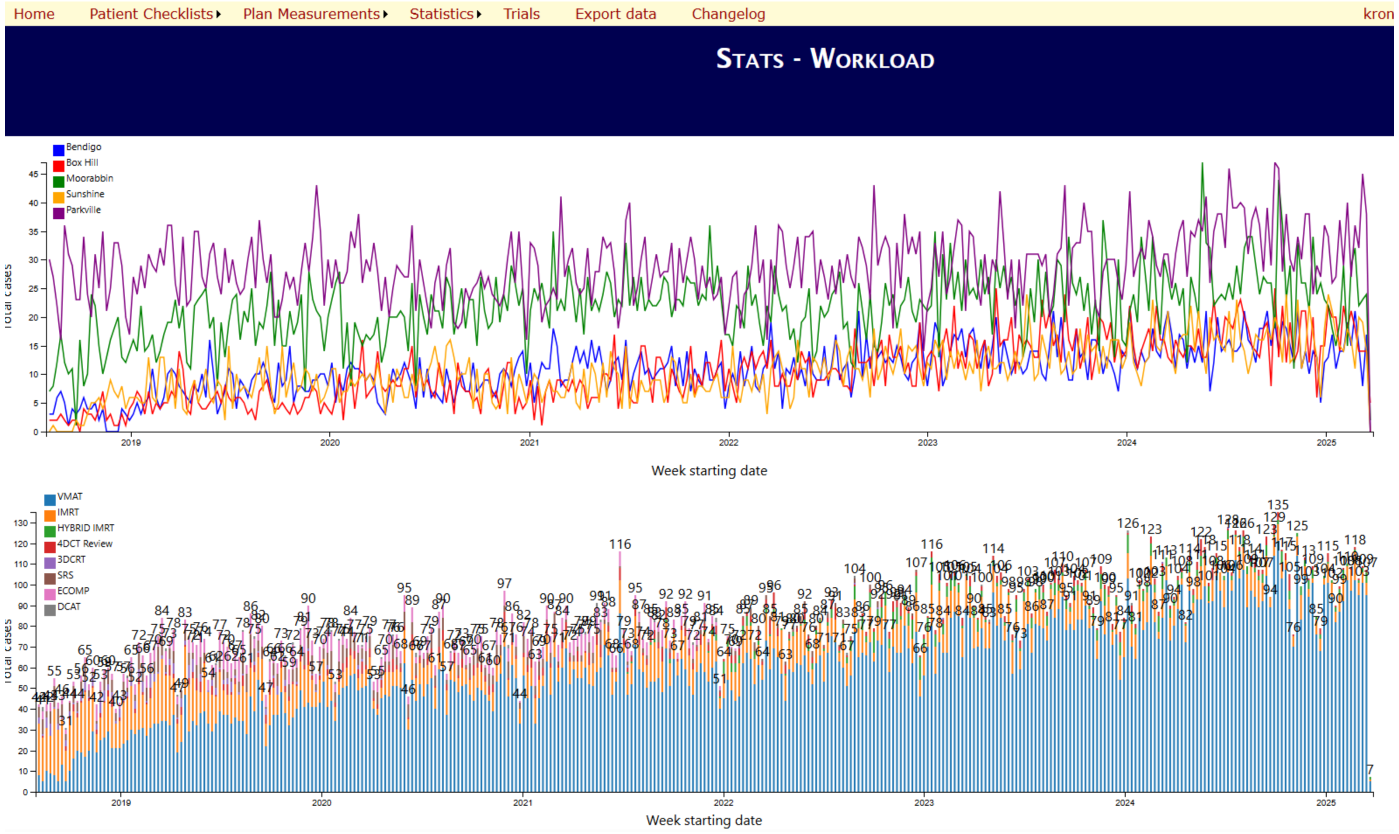
- Quite variable
- Up to 14 hours per week per linac = about 0.5 EFT per linac for plan checking
- Mean about 0.15 EFT
- Assume 1.5 physicists per linac → plan check was 10% of workload

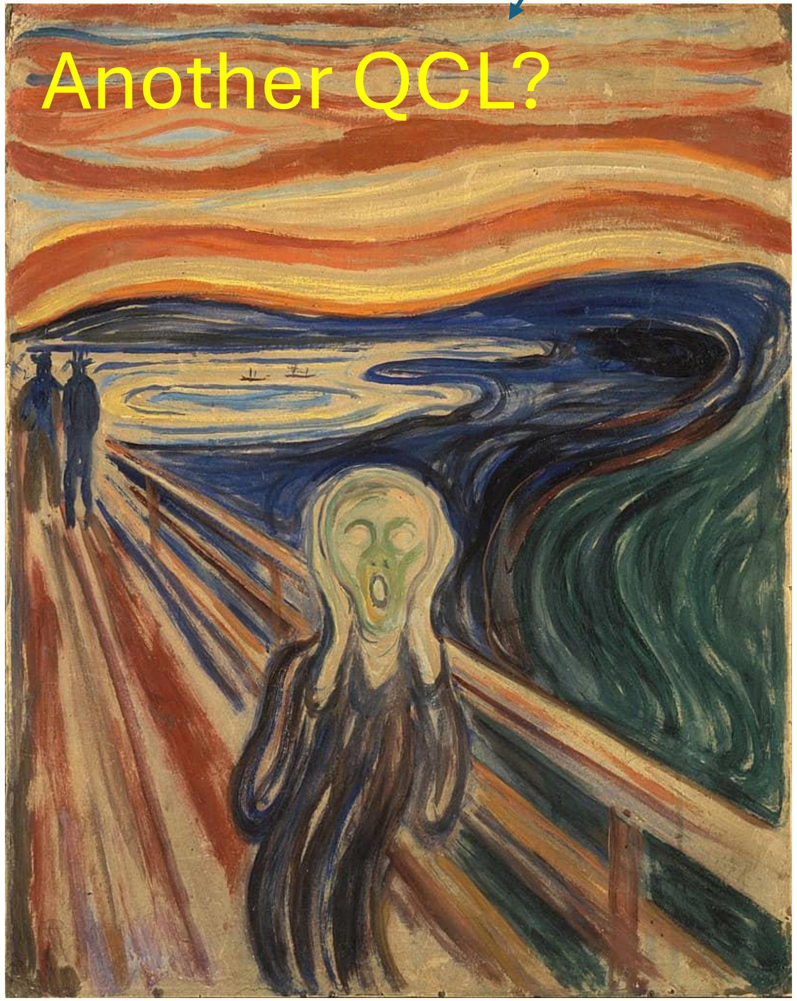


What about today?

MOSAIQ jargon for alerting physics to a new task

Plan checks are the largest component of our workload





PMCC ROMP workforce model (2024)

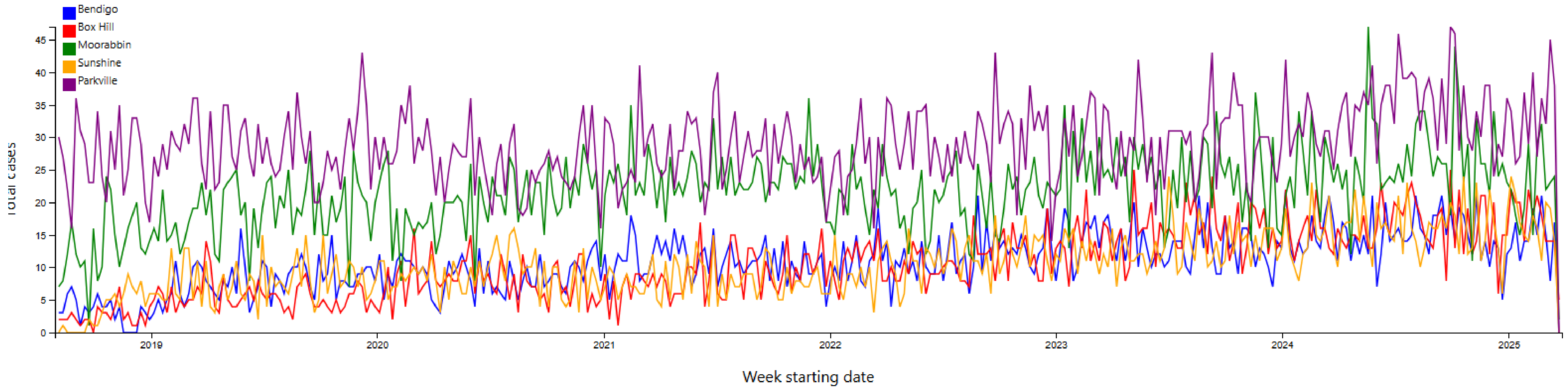
Equipment	# linacs, multiple photons, electrons, MLC		includes imaging	1		0	0	0	0	0	0	1	0.3	0	0	unit	0.3			
related	# high end linac		includes motion	14		2	0.8	2	0.8	5	2	3	1.2	2	0.8	unit	0.4			
	# specialised linacs		stereotactic	1		0	0	0	0	1	0.5	0	0	0	0	unit	0.5			
	# Gammaknife			1		0	0	0	0	1	0.4	0	0	0	0	unit	0.4			
			all MV units	17		2		2		7		4		2						
	# SGRT systems			11		2	0.2	2	0.2	3	0.3	2	0.2	2	0.2	unit	0.1			
	# superficial			4		1	0.05	0	0	1	0.05	1	0.05	1	0.05	unit	0.05			
	# CT for planning			7		1	0.05	1	0.05	2	0.1	2	0.1	1	0.05	unit	0.05	incl 4D		
	# PET CT for planning			3.2		0.2	0.02	0	0	2	0.2	1	0.1	0	0	unit	0.1	incl 4D	fractional means located elsewhere but QA done	
	# MRI for planning			0.6		0	0	0	0	0.4	0.08	0.2	0.04	0	0	unit	0.2		fractional means located elsewhere but QA done	
	# brachytherapy (seeds=1)			3		0	0	0	0	2	0.4	1	0.2	0	0	unit	0.2			
	# ROI (mosaiq - network)		hardware component only	5		1	0.05	1	0.05	1	0.05	1	0.05	1	0.05	unit	0.05			
	# planning systems		hardware component only	4		0.2	0.04	0.2	0.04	3.2	0.64	0.2	0.04	0.2	0.04	unit	0.2		Eclipse split across all campuses	
	# independent MU checker		hardware component only	10		2	0.1	2	0.1	2	0.1	2	0.1	2	0.1	unit	0.05		Radcalc accounted for at Sunshine	
	# other equipment (immobilisation, 3D printer, block cutter)		hardware component only	6								1	0.05	1	0.05	unit	0.05			
	# servers		hardware component only	6								1	0.02	2	0.04	unit	0.02			
	total equipment related			*11.46*									*2.45*		*1.38*					
																per	required estimate			
Activity	# patients	%	estimates	7000								1900	1.9	900	0.9	1000	1		# patients	
related	# IMRT/VMAT	81%	patient specific QA	5700		700	0.875	700	0.875	2000	2.5	1600	2	700	0.875	800	1		# IMRT/VMAT	in addition to total patients
	# SABR	6%	patient specific QA	440		30	0.075	30	0.075	250	0.625	100	0.25	30	0.075	400	1		# SABR	in addition to total patients
	# DIBH/DEBH	6%	breath hold (not too complex)	390		50	0.05	50	0.05	120	0.12	120	0.12	50	0.05	1000	1		# DIBH/DEBH	in addition to total patients
	# 4DCT for review		motion management support	330		40	0.08	40	0.08	120	0.24	80	0.16	50	0.1	500	1		# 4DCT for review	
	# SRS		typically short turn around	200	includes GK	30	0.15	30	0.15	50	0.25	60	0.3	30	0.15	200	1		# SRS	in addition to total patients
	# Gammaknife SRS		special workflow	200		0	0	0	0	200	0.5	0	0	0	0	400	1		# Gammaknife SRS	
	# complex simulation/CT		4D contrast, CPAP	130		10	0.025	10	0.025	60	0.15	40	0.1	10	0.025	400	1		# complex simulation/CT	
	# complex motion management		gating, breath hold	110		10	0.05	10	0.05	60	0.3	20	0.1	10	0.05	200	1		# complex motion management	
	# eye tracker patients		multi fraction trial	10		0	0	0	0	10	0.1	0	0	0	0	100	1		# eye tracker pa	in addition to total patients
	# adaptive RT		advise on fusion, dose accum	70		10	0.05	10	0.05	20	0.1	20	0.1	10	0.05	200	1		# adaptive RT	in addition to total patients
	# TBI		plan by physics	40		0	0	0	0	40	0.4	0	0	0	0	100	1		# TBI	in addition to total patients
	# TSET		physics attendence 3 fraction:	30		0	0	0	0	30	0.15	0	0	0	0	200	1		# TSET	in addition to total patients
	# SXRT/DXRT patients			190		40	0.08	0	0	60	0.12	50	0.1	40	0.08	500	1		# SXRT/DXRT pa	in addition to total patients
	# HDR brachy		simple brachy (eg vault)	125		0	0	0	0	125	0.3125	0	0	0	0	400	1		# HDR brachy	
	# HDR brachy		complex brachy (eg skin, T+O)	100		0	0	0	0	100	0.5	0	0	0	0	200	1		# HDR brachy	
	# HDR real time US		each insertion counted as a p	120		0	0	0	0	120	0.6	0	0	0	0	200	1		# HDR real time US	
	# HDR intraoperative TxT			20		0	0	0	0	20	0.2	0	0	0	0	100	1		# HDR intraoperative TxT	
	# eBrachy breast		intraoperative Xoft	10			0	0	0	0	0	10	0.05	0	0	200	1		# eBrachy breast	
	# LDR prostate			5			0	0	0	5	0.025	0	0	0	0	200	1		# LDR prostate	
	# LDR eye plaques		incl. eye plaque 10 and prosta	50										0	0	100	1		# LDR eye plaques	
	# various consults		pacemaker, breast implants	160										20	0.04	500	1		# various consults	
	# 3D printed bolus / beam modifyiers		testing for CT number and hor	230										30	0.03	1000	1		# 3D printed bolus / beam modifyiers	
	# in vivo dosimetry		TLD, radiochromic and Mosfet	220										30	0.075	400	1		# in vivo dosimetry	
	total patient related			*23.3175*											*2.5*					

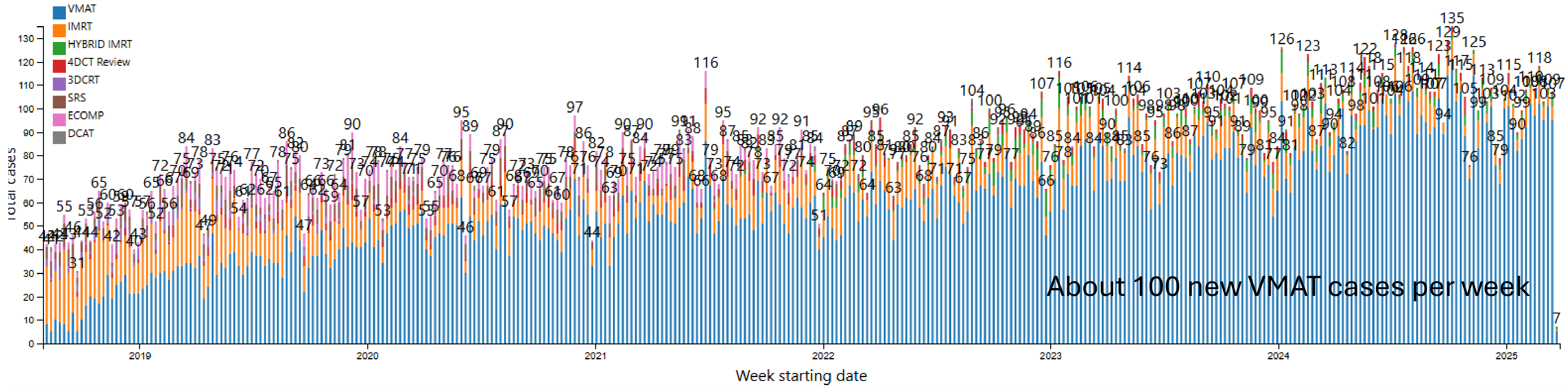
Kron Tomas: patient related work is about 2x that of machine related

5 campuses equipment: 11.5 EFT required

Patient related: 23.3 EFT required

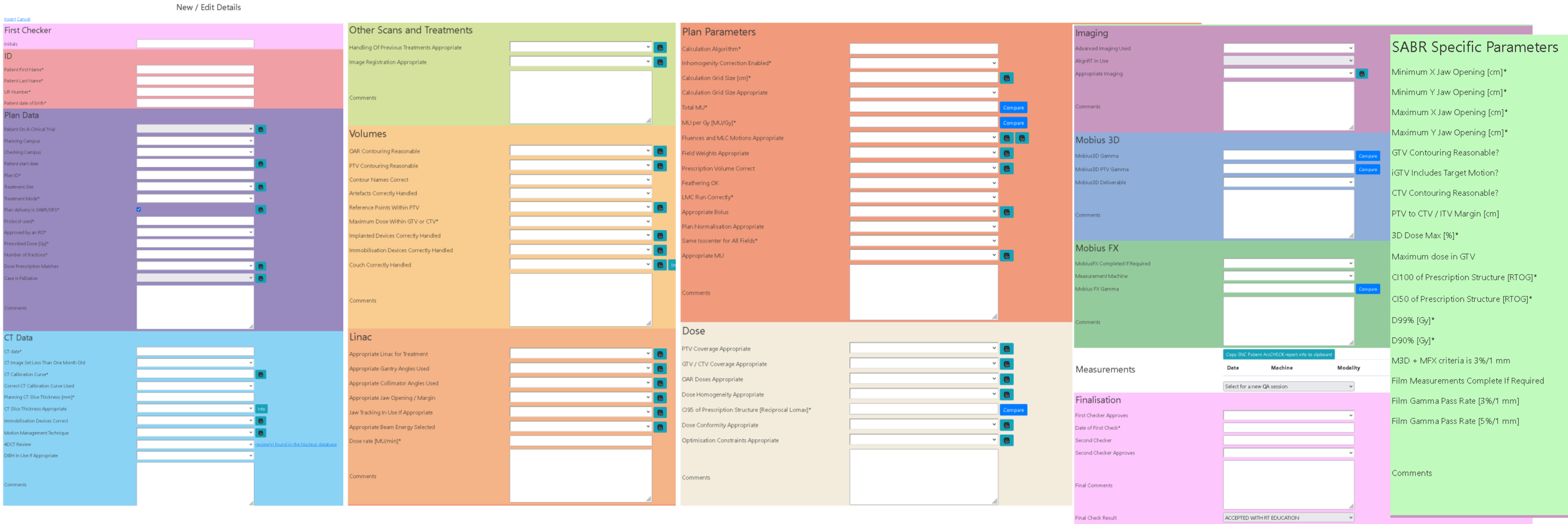
Different times: no more spreadsheets





Plan check by physicist at Peter Mac

- Physics at Peter Mac does a plan check for all dynamic plans and small field
- Check list (long, some overlap with planner check)
- QA Nucleus database (Keith Offer)



Plan check is non-negotiable

Australian Government
Australian Radiation Protection and Nuclear Safety Agency

arpansa

3.2.20 The Responsible Person must ensure that:

a. treatment planning procedures are followed

b. all treatment planning equipment is tested

c. the basic data for each available treatment planning computer program are verified by a medical physicist:

   i. on initial acceptance

   ii. after any change or upgrade

d. patient-specific independent calculations of monitor units or treatment time are performed for radiotherapy.

Code for Radiation Protection in Medical Exposure

Radiation Protection Series C-5

Plan check is non-negotiable

Australian Government
Australian Radiation Protection and Nuclear Safety Agency
arpansa

3.2.20 The Responsible Person must ensure that:

a. treatment planning procedures are fo

b. all treatment planning equipment is te

c. the basic data for each available treat medical physicist:

i. on initial acceptance

ii. after any change or upgrade

d. patient-specific independent calculati performed for radiotherapy.

Billing of radiotherapy services in Australia requires plan checks (MBS)

Protocols for documenting quality assurance processes for treatment plans

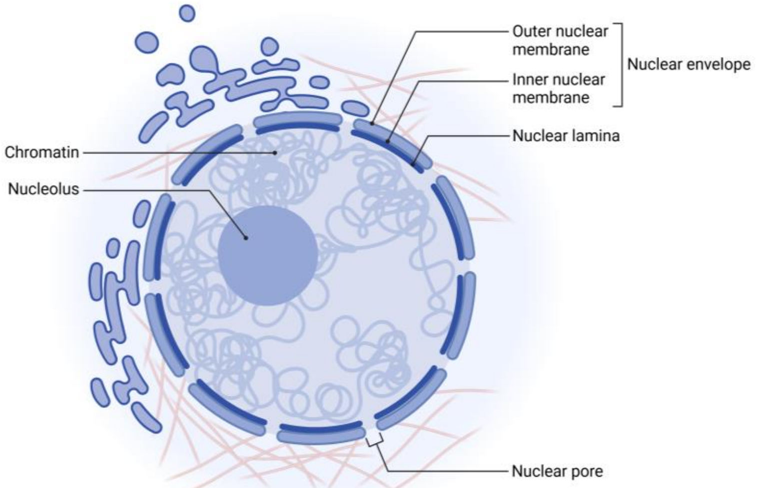
Treatment plans should be produced using quality assurance processes to ensure, where appropriate:

a. Data within the oncology information system is accurate; and
b. Data transfer to the Oncology Information System has been completed without any loss of data integrity; and
c. The plan is deliverable without loss of dosimetric accuracy on the radiation therapy apparatus which will be used for clinical delivery (including particular consideration given to geometric accuracy where tight margins or steep dose gradient are employed); and
d. The dose calculation of the treatment plan (including on the patient planning images) is accurate; and
e. The accuracy of any image fusions performed; and
f. The final treatment plan is validated by a radiation therapist or medical physicist, using quality assurance processes, with the plan approved by the radiation oncologist prior to delivery.

The quality assurance processes should be established, maintained and performed by radiation therapists and medical physicists and should be formally documented.

QA Nucleus

- The plan checks are recorded in a database that becomes useful for other work
  - Research
  - Revising our checklist
  - Measuring impact
  - Improvement within tumour streams or planning groups



How effective is the plan checking?

- Assessment of gaps against MPPG11a / other policies / ACPSEM advice on OIS / brainstorming
- Analysis of 12 months of physics plan checks
  - Number of replans
  - Number of times plans were discussed (quality improvement activity)
- Risk assessment per item using TG-100

Actions after checks

- Replan request rate ~ 1.3% (about 100 patients per year)
- Per plan advice given rate ~4.3%
  - This doesn't include advice for consults before the check

A Roman centurion looked after roughly 100 soldiers

Example risk assessments as per TG-100

Conventional	RPN	SABR/SRS	RPN
Artefacts Correctly Handled	252	Image Registration Appropriate	378
Optimisation Constraints Appropriate	196	Appropriate Imaging	280
Fluences and MLC Motions Appropriate	180	Artefacts Correctly Handled	252
Implanted Devices Correctly Handled	140	Optimisation Constraints Appropriate	252
Appropriate Imaging	112	Implanted Devices Correctly Handled	210
Dose Prescription Matches	112	Appropriate MU	210
Appropriate Bolus	100	iGTV Includes Target Motion?	210
PTV Contouring Reasonable	96	Correct CT Calibration Curve Used	200
Calculation Grid Size Appropriate	96	4DCT Review	196
Appropriate MU	80	PTV Contouring Reasonable	168

Example risk assessments as per TG-100

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Only valid for Peter Mac circumstances, use with caution

Presented Platform : Global Alliance for Medical Physics Education and Research (GAMPER)

Formal multidisciplinary review

- Workload consolidation
- Reduction of overlap between checks of different professional groups
- New system with two categories

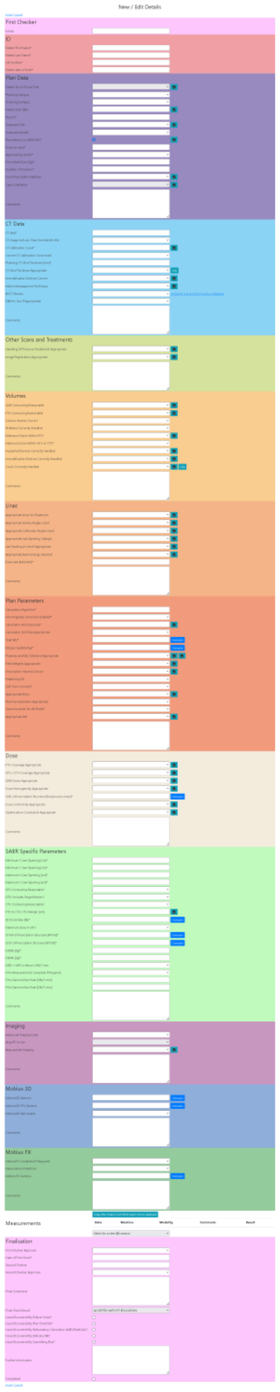
Category 1	Category 2
Standard VMAT, IMRT and DCAT techniques for radical and palliative fractionated cases.	Paediatrics, SABR/SRS, FB gating, specified clinical trials, Gamma Knife, reirradiation and new techniques

- *"For Category 1 plans, RT's are responsible for checking all aspects of plan quality, with Physics checks focusing on safety, robustness and deliverability of the plan.*
- *For Category 2 plans, both RT and Physics will review the contouring and dosimetric plan quality, as well as safety, robustness and deliverability."*

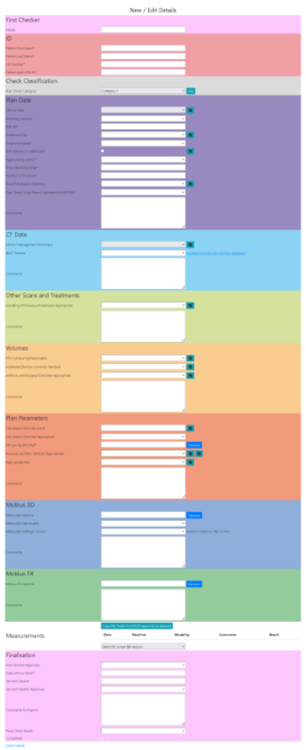
New system

- Went live late March
- We don’t time plan checks; anecdotally at least 10 minutes saved for category 1
- 1274 checks done in new list, 919 categorised as category 1
  - > 150 hours saved, likely already paid for itself time wise

Original



Eg: Light green is SABR/SRS



Cat 1

Cat 2

This has suited PMCC in 2025...

- May not work for other centres
- Continuous monitoring required
- Depends on
  - Staffing numbers
  - Staff training and experience
  - Patient profile
  - Technologies, techniques
  - Workload
  - Other checks

This has suited PMCC in 2025...

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  - Staffing numbers
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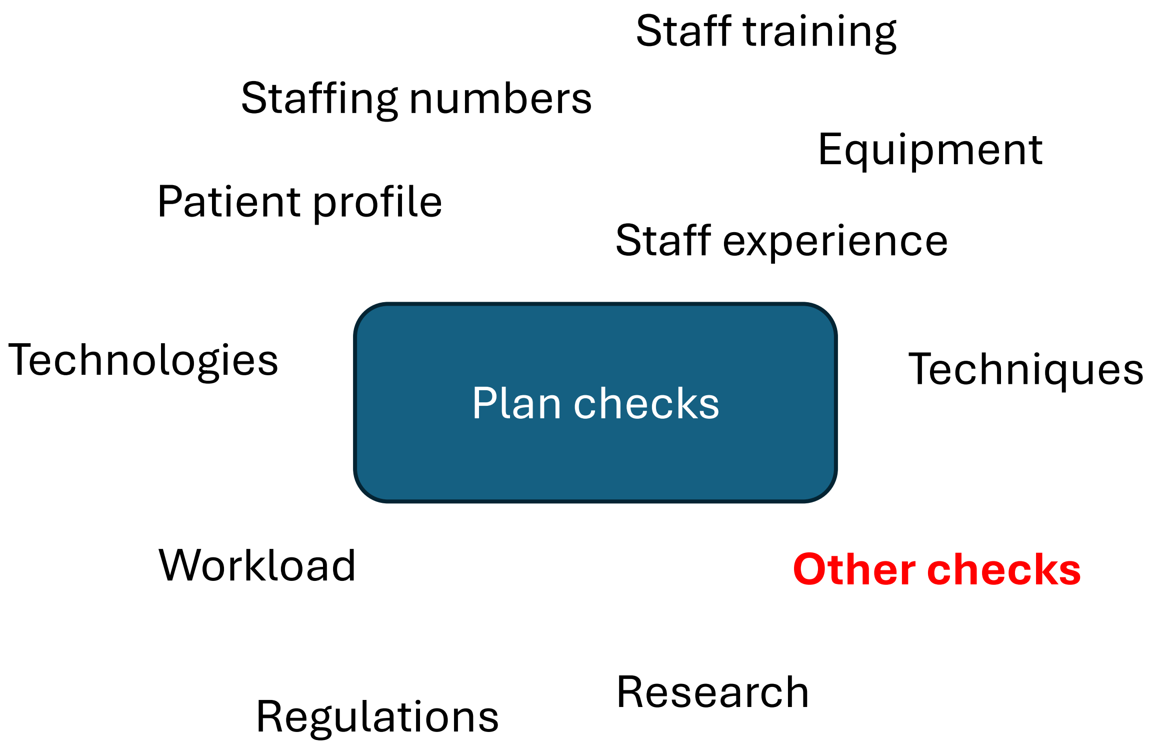
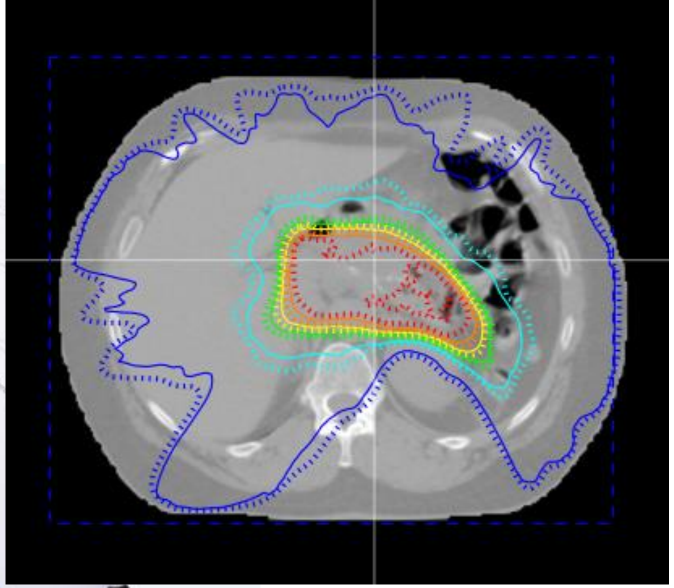


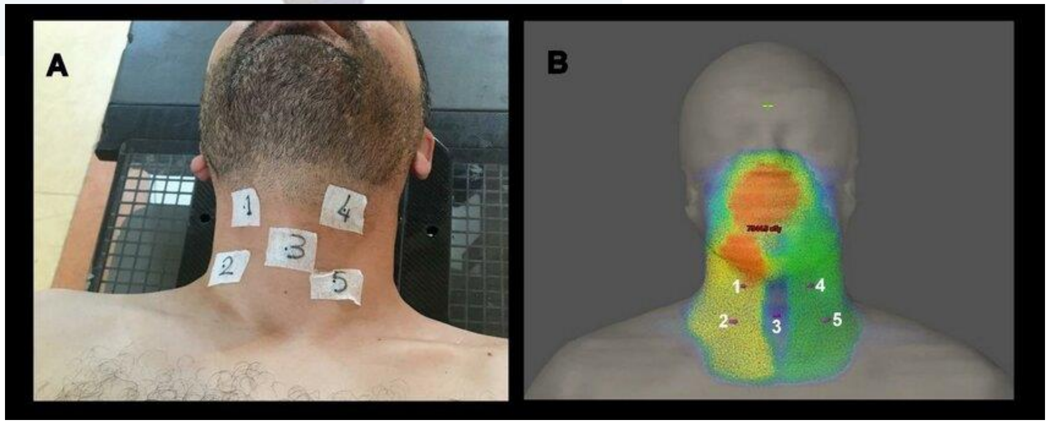
Plan checks are part of patient specific QA

- Radiotherapy is (and has been for many decades) personalised medicine
- Every treatment plan is different
- QA is required:
  - Are there any underlying problems with the plan generation?
    - Patient related: Imaging, motion, immobilisation, timing, obesity, …
    - Machine related: Choice of modality, beam model, optimisation, …
  - Can it be delivered?
  - Are there better solutions?
  - Should we change/improve practice?

Patient specific QA

- Plan review
  - Contours
  - Motion
  - Beam arrangement
- Independent dose calculation
- Phantom measurement
- Image guidance
- In vivo dosimetry





Is it any good?

- No good correlation between ‘pass’ of institutional QA and ‘pass’ by external auditor

A

		IROC Houston: Fail	IROC Houston: Pass
Inst QA	Fail	2	3
	Pass	120	730

International Journal of Radiation Oncology biology • physics

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Physics Contribution

Institutional Patient-specific IMRT QA Does Not Predict Unacceptable Plan Delivery

Stephen F. Kry, PhD,* Andrea Molineu, MS,* James R. Kerns, MS,*,† Austin M. Faught, PhD,*,† Jessie Y. Huang, BS,*,† Kiley B. Pulliam, MS,*,† Jackie Tonigan, MS,*,† Paola Alvarez, MS,* Francesco Stingo, PhD,†,‡ and David S. Followill, PhD*,†

*Imaging and Radiation Oncology Core at Houston, Department of Radiation Physics, The University of Texas MD Anderson Cancer Center, Houston, Texas; †The University of Texas Health Science Center Houston, Graduate School of Biomedical Sciences, Houston, Texas; and ‡Department of Biostatistics, The University of Texas MD Anderson Cancer Center, Houston, Texas

Received Apr 18, 2014, and in revised form Aug 14, 2014. Accepted for publication Aug 18, 2014.

Summary

We compared institutional patient-specific intensity modulated radiation therapy quality assurance (IMRT QA) results with those of the Imaging and Radiation Oncology Core at Houston (IROC Houston) phantom results. Although both tools are designed to test the accuracy of IMRT plan delivery, we found that no IMRT QA device could reasonably predict whether a plan would fail the IROC Houston phantom. This indicates that IMRT QA is not a suitable replacement for an independent credentialing phantom and raises concerns about the level of

Purpose: To determine whether in-house patient-specific intensity modulated radiation therapy quality assurance (IMRT QA) results predict Imaging and Radiation Oncology Core (IROC)-Houston phantom results.

Methods and Materials: IROC Houston's IMRT head and neck phantoms have been irradiated by numerous institutions as part of clinical trial credentialing. We retrospectively compared these phantom results with those of in-house IMRT QA (following the institution's clinical process) for 855 irradiations performed between 2003 and 2013. The sensitivity and specificity of IMRT QA to detect unacceptable or acceptable plans were determined relative to the IROC Houston phantom results. Additional analyses evaluated specific IMRT QA dosimeters and analysis methods.

Results: IMRT QA universally showed poor sensitivity relative to the head and neck phantom, that is, poor ability to predict a failing IROC Houston phantom result. Depending on how the IMRT QA results were interpreted, overall sensitivity ranged from 2% to 18%. For different IMRT QA methods, sensitivity ranged from 3% to 54%. Although the observed sensitivity was particularly poor at clinical thresholds (eg 3% dose difference or 90% of pixels passing gamma), receiver operator characteristic analysis indicated that no threshold showed good sensitivity and specificity for the devices evaluated.

Conclusions: IMRT QA is not a reasonable replacement for a credentialing phantom. Moreover, the particularly poor agreement between IMRT QA and the IROC Houston phantoms highlights surprising inconsistency in the QA process.

New tools to improve...

- Plan checks are part of this learning process
- No QA for plan checks as yet?

Radiotherapy and Oncology 171 (2022) 121–128

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journal homepage: www.thegreenjournal.com

Original Article

SEAFARER – A new concept for validating radiotherapy patient specific QA for clinical trials and clinical practice

Joerg Lehmann [a,b,c,*], Mohammad Hussein [d], Miriam A. Barry [d], Shankar Siva [e], Alisha Moore [f], Michael Chu [g], Patricia Díez [h], David J. Eaton [i], Jeffrey Harwood [j], Peta Lonski [e], Elizabeth Claridge Mackonis [k], Carole Meehan [l], Rushil Patel [m], Xenia Ray [n], Maddison Shaw [o,p], Justin Shepherd [q], Gregory Smyth [r], Therese S. Standen [b], Brindha Subramanian [s], Peter B. Greer [b,c], Catharine H. Clark [d,t,u]

[a] University of Sydney; [b] Calvary Mater Newcastle; [c] University of Newcastle, Australia; [d] National Physical Laboratory; [e] Peter MacCallum Cancer Center, Melbourne; [f] TROG Cancer Research, Newcastle, Australia; [g] Velindre Cancer Centre, Cardiff; [h] National Radiotherapy Trials Quality Assurance (RTTQA) Group; [i] Guy's and St Thomas's Hospitals, London, UK; [j] Canberra Health Services; [k] Chris O Brien Lifehouse, Sydney, Australia; [l] The Royal Marsden NHS Trust Hospital; [m] Mount Vernon Cancer Centre, London, UK; [n] University of California San Diego Moores Cancer Center, USA; [o] Australian Clinical Dosimetry Service, Australian Radiation Protection and Nuclear Safety Agency; [p] RMIT University, Melbourne, Australia, Australia; [q] Royal Adelaide Hospital, Australia; [r] The Institute of Cancer Research and The Royal Marsden NHS Foundation Trust, London, UK; [s] Genesis Care, Melbourne; [t] University College Hospital, London; and [u] University College London

A R T I C L E I N F O

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Keywords:
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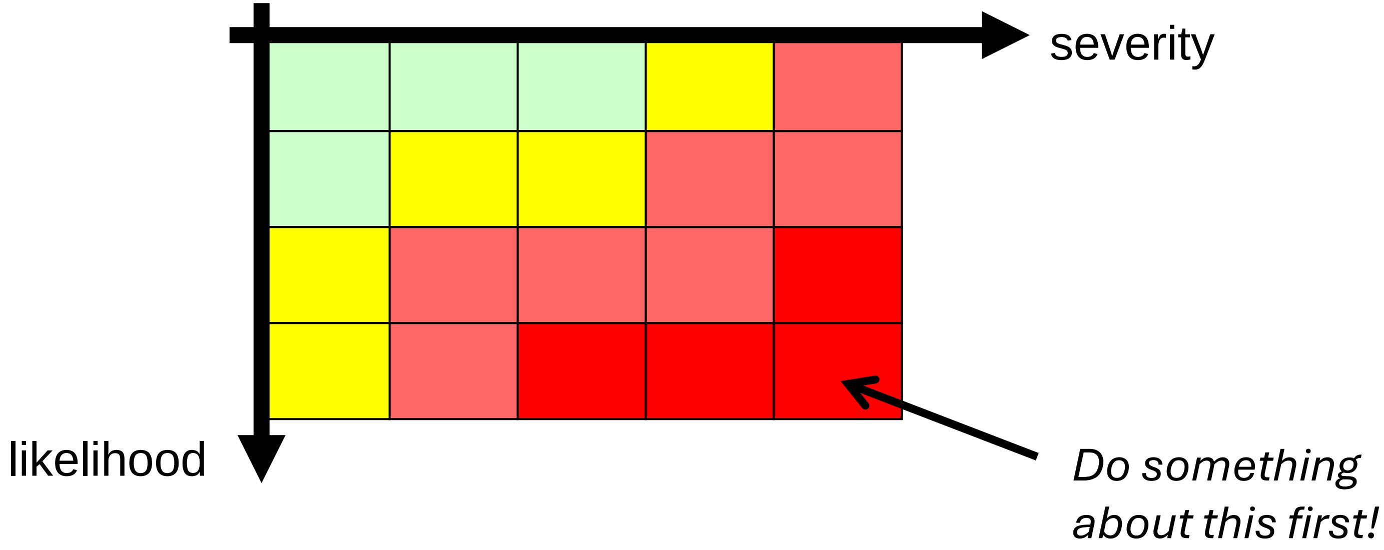
Dosimetry audits
Sensitivity
Patient specific quality assurance
Intensity modulated radiotherapy
SEAFARER

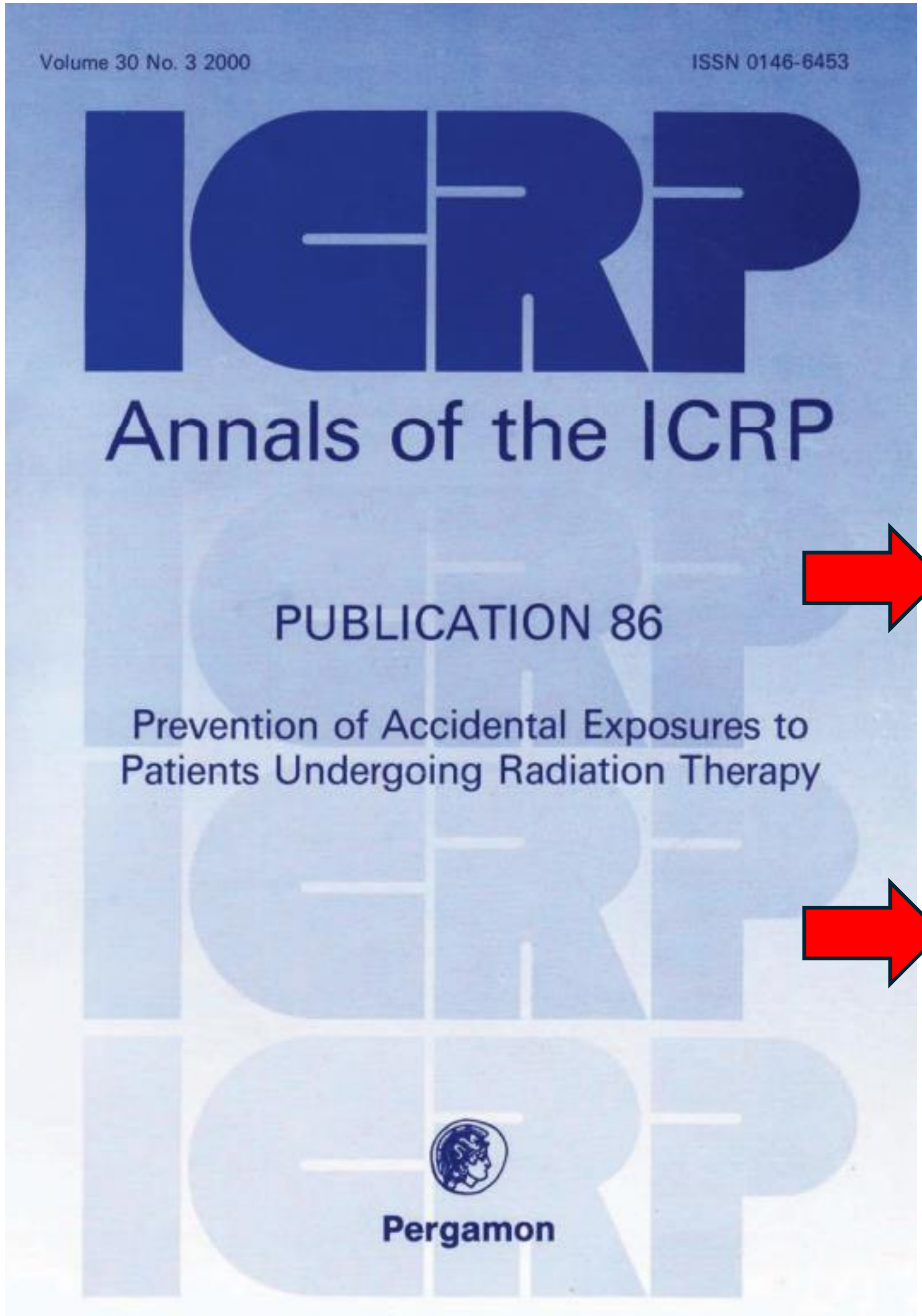
A B S T R A C T

Background: The quality of radiotherapy delivery has been shown to significantly impact clinical outcomes including patient survival. To identify errors, institutions perform Patient Specific Quality Assurance (PSQA) assessing each individual radiotherapy plan prior to starting patient treatments. Externally administered Dosimetry Audits have found problems despite institutions passing their own PSQA. Hence a new audit concept which assesses the institution's ability to detect errors with their routine PSQA is needed.
Methods: Purposefully introduced edits which simulated treatment delivery errors were embedded into radiation treatment plans of participating institutions. These were designed to produce clinically significant changes yet were mostly within treatment delivery specifications. Actual impact was centrally assessed for each plan. Institutions performed PSQA on each plan, without knowing which contained errors.
Results: Seventeen institutions using six radiation treatment planning systems and two delivery systems performed PSQA on twelve plans each. Seventeen erroneous plans (across seven institutions) passed PSQA despite causing >5% increase in spinal cord dose relative to the original plans. Six plans (from four institutions) passed despite a >10% increase.
Conclusions: This novel audit concept evolves beyond testing an institution's ability to deliver a single test case, to increasing the number of errors caught by institutions themselves, thus increasing quality of radiation therapy and impacting every patient treated. Administered remotely this audit also provides advantages in cost, environmental impact, and logistics.

Selecting what should be checked

- Prioritization based on ‘scientific’ risk management
- How likely is it to happen and how severe are the consequences





Identified risks

Table 3. Classes and frequencies of accidental exposure in radiotherapy

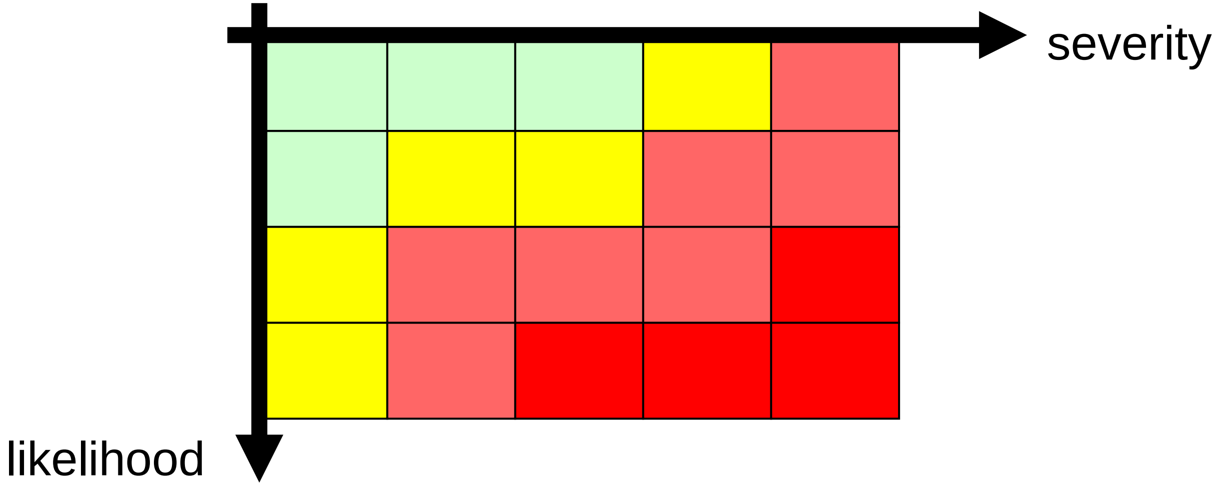
Accidental exposures in external beam therapy	No. of cases	Percentage of cases (rounded)
Equipment problems	3	6.5
Maintenance	3	6.5
Calibration of the beams	14	30
Treatment planning and dose calculation	13	28
Simulation	4	9
Treatment set-up and delivery	9	20 (**)
Total	46 (*)	100
Accidental exposures in brachytherapy		No. of cases
Equipment and source problems	5	15
Source order and delivery, calibration, and acceptance	3	9
Source storage and preparation for the treatment	5	15
Treatment planning and dose calculation	6	18
Treatment delivery	11	34
Source removal and return	3	9
Total	33 (*)	100

*The number of accidents in the table are fewer in number than in the source publications, since the source publications include events with unsealed sources and accidents involving the public.

**It is likely that errors in the treatment set-up are more frequent than tabulated, since many instances probably remain unreported, especially if the consequences are moderate, i.e., affecting one or a few fractions.

Selecting what should be done

- Prioritization based on ‘scientific’ risk management
- How likely is it to happen and how severe are the consequences



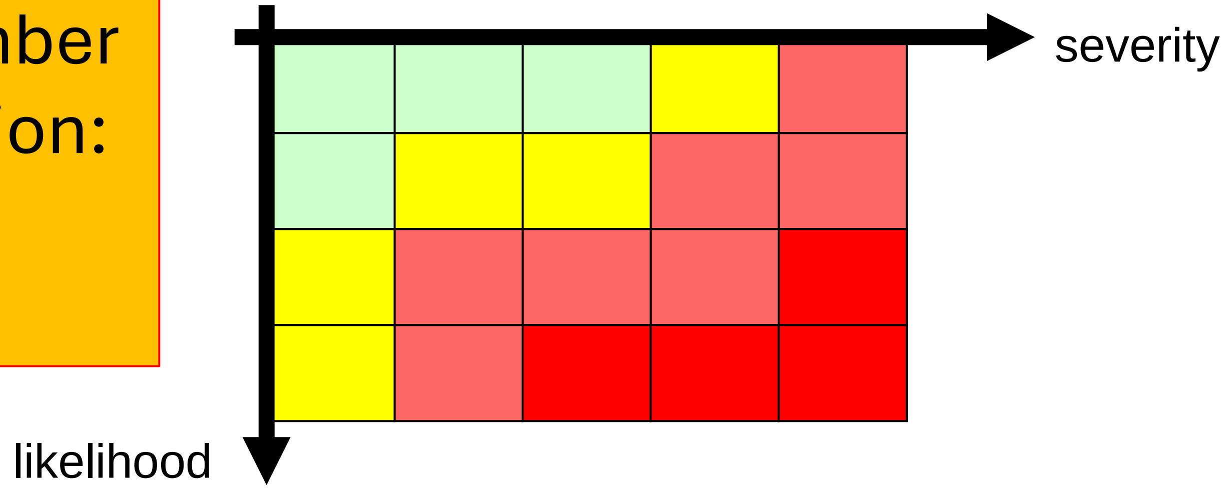
Often add third dimension: How easily is the problem to go undetected?

Selecting what should be done

- Prioritization based on ‘scientific’ risk management
- How likely is it to happen and how severe are the consequences

Risk priority number helps prioritisation:

L x S x U



Often add third dimension: How easily is the problem to go undetected?

Strategies for effective physics plan and chart review in radiation therapy: Report of AAPM Task Group 275

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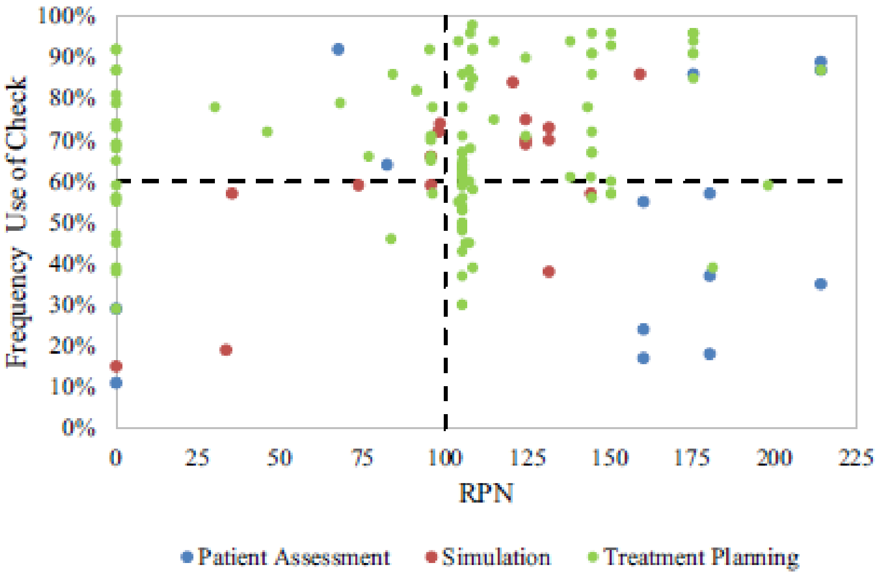
(Received 9 August 2019; revised 3 January 2020; accepted for publication 8 January 2020; published 15 April 2020)

Background: While the review of radiotherapy treatment plans and charts by a medical physicist is a key component of safe, high-quality care, very few specific recommendations currently exist for this task.
Aims: The goal of TG-275 is to provide practical, evidence-based recommendations on physics plan and chart review for radiation therapy. While this report is aimed mainly at medical physicists, others may benefit including dosimetrists, radiation therapists, physicians and other professionals interested in quality management.
Methods: The scope of the report includes photon/electron external beam radiotherapy (EBRT), proton radiotherapy, as well as high-dose rate (HDR) brachytherapy for gynecological applications (currently the highest volume brachytherapy service in most practices). The following review time points are considered: initial review prior to treatment, weekly review, and end-of-treatment review. The Task Group takes a risk-informed approach to developing recommendations. A failure mode and effects analysis was performed to determine the highest-risk aspects of each process. In the case of photon/electron EBRT, a survey of all American Association of Physicists in Medicine (AAPM) members was also conducted to determine current practices. A draft of this report was provided to the full AAPM membership for comment through a 3-week open-comment period, and the report was revised in response to these comments.

Results: The highest-risk failure modes included 112 failure modes in photon/electron EBRT initial review, 55 in weekly and end-of-treatment review, 24 for initial review specific to proton therapy, and 48 in HDR brachytherapy. A 103-question survey on current practices was released to all AAPM members who self-reported as working in the radiation oncology field. The response rate was 33%. The survey data and risk data were used to inform recommendations.
Discussion: Tables of recommended checks are presented and recommendations for best practice are discussed. Suggestions to software vendors are also provided.
Conclusions: TG-275 provides specific recommendations for physics plan and chart review which should enhance the safety and quality of care for patients receiving radiation treatments. © 2020 *American Association of Physicists in Medicine* [https://doi.org/10.1002/mp.14030]



Prospective Risk Management

The report of Task Group 100 of the AAPM: Application of risk analysis methods to radiation therapy quality management

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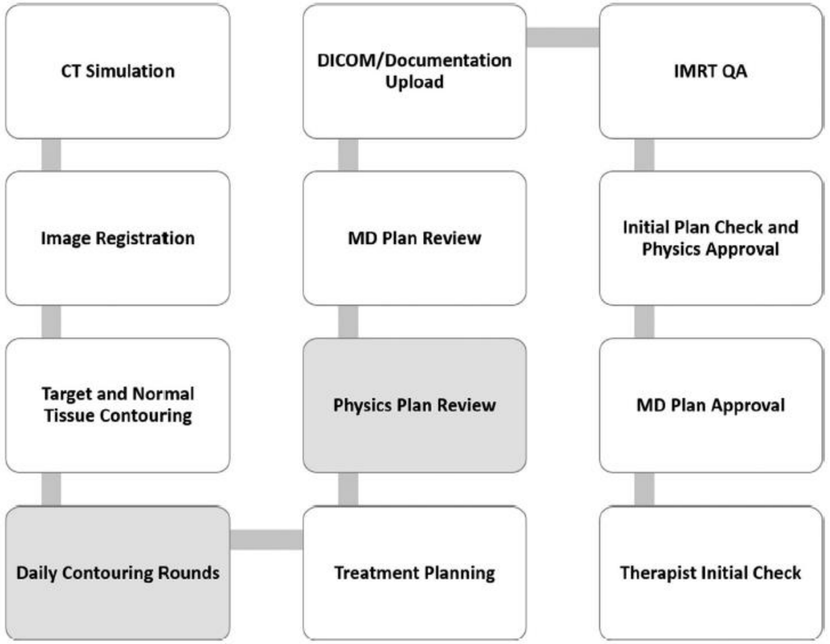
(Received 13 May 2015; revised 13 March 2016; accepted for publication 14 March 2016; published 15 June 2016)

AAPM Report 283

- Published 2016
- > 10 years in the making
- Long (54 pages + appendices)
- Long awaited
- Failure Mode and Effects Analysis (FMEA) approach

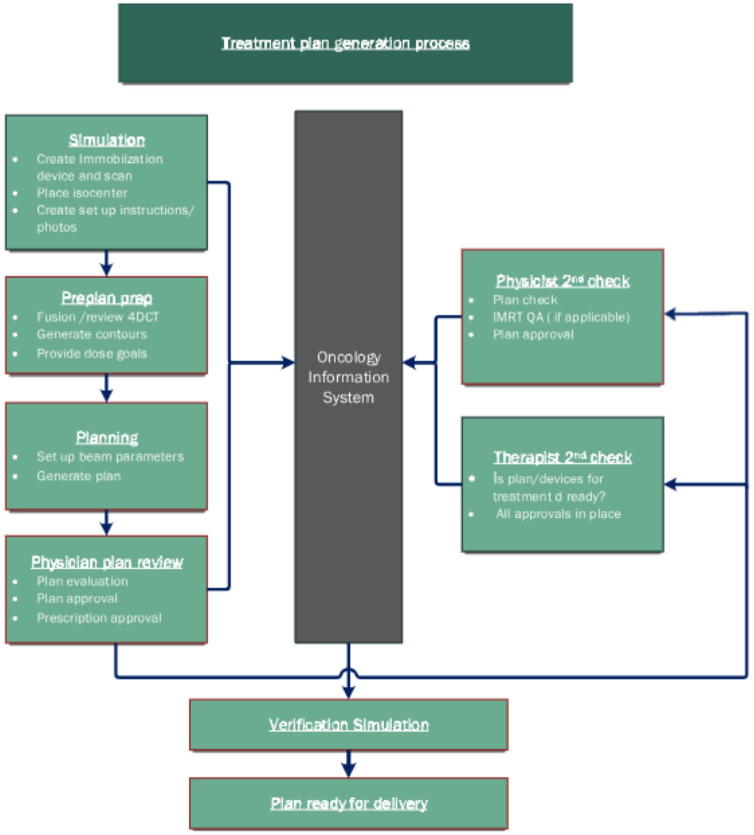
Prospective risk analysis: Failure Mode and Effect Analysis

Start is a process map



Riegel et al
JACMP 22

Rassiah et al
JACMP 2020



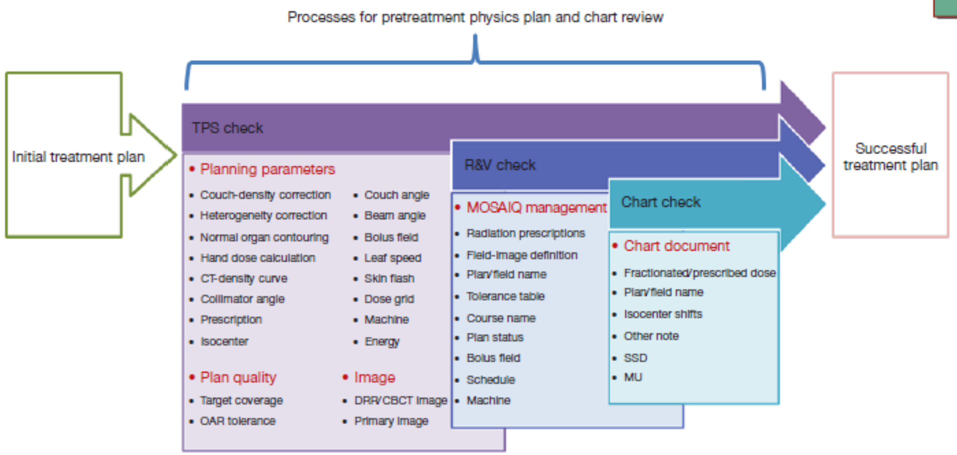
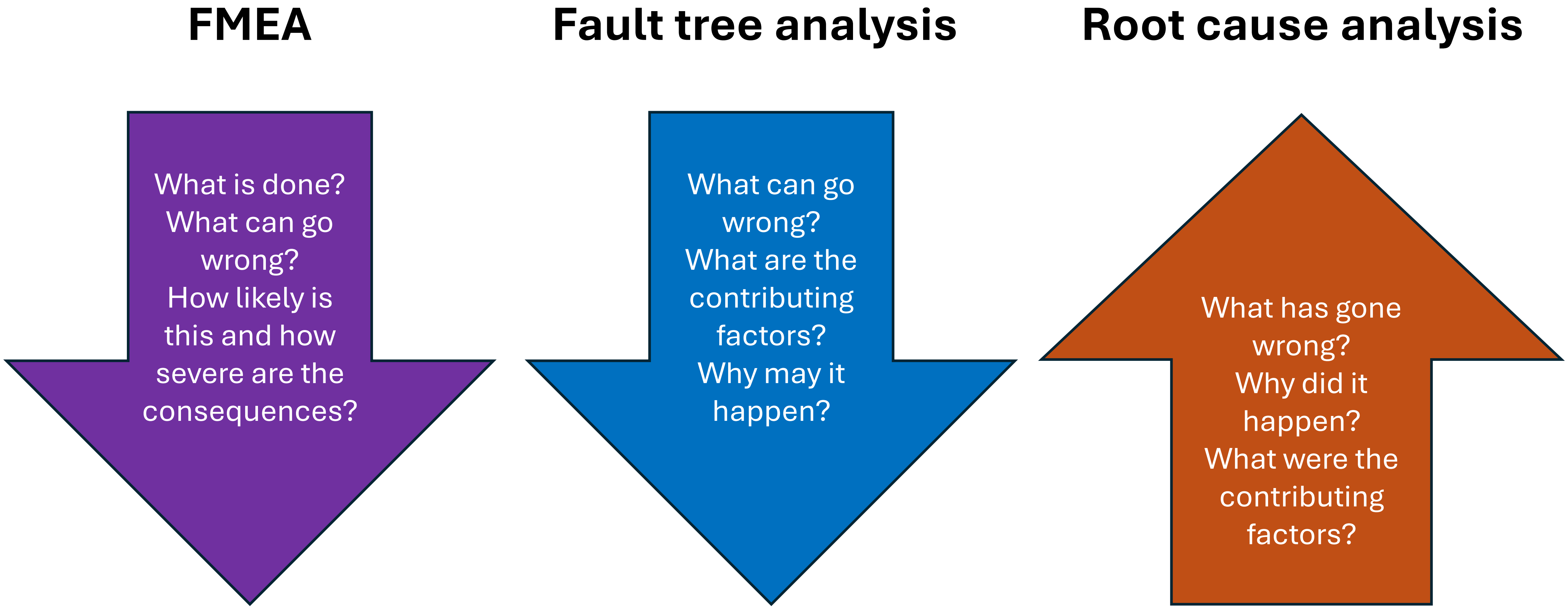


Figure 1 PTPCR process map. PTPCR, pretreatment physics plan and chart review; TPS, treatment planning system; R&V, record and verify; CT, computed tomography; OAR, organ at risk; MU, monitor unit; DRR, digitally reconstructed radiograph; CBCT, cone-beam computed tomography; SSD, source-to-surface distance.

Huang et al
TRO 22



Simplified scheme of two prospective and one retrospective approach to risk management

Literature galore for FMEA

Original Article

Failure mode and effects analysis for errors detected during pretreatment physics plan and chart review in external beam radiotherapy

Sheng-Fang Huang[1,2#], Hao-Wen Cheng[1,2#], Jo-Ting Tsai[1,2,3], Chun-Yuan Kuo[1,2], Chih-Chieh Chang[1], Li-Jhen Chen[1], An-Cheng Shiau[4,5,6], Yu-Jen Wang[1,7,8], Ming-Hsien Li[1,3]

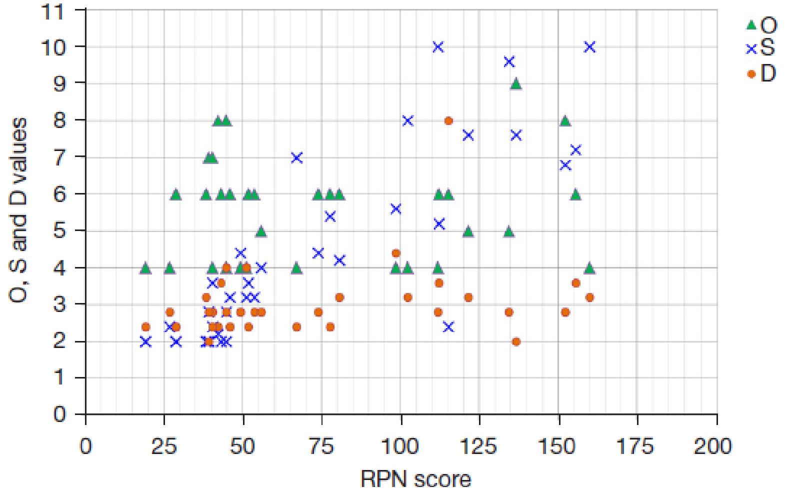


Figure 2 Distribution of O, S, and D values versus RPN score for FMs identified in this study. The overlaid FMs are expressed as one symbol. O, occurrence; S, severity; D, detectability; RPN, risk priority number; FMs, failure modes.

TRO 22

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JOURNAL OF APPLIED CLINICAL MEDICAL PHYSICS

AAPM REPORTS & DOCUMENTS

Medical Physics Practice Guideline (MPPG) 11.a: Plan and chart review in external beam radiotherapy and brachytherapy

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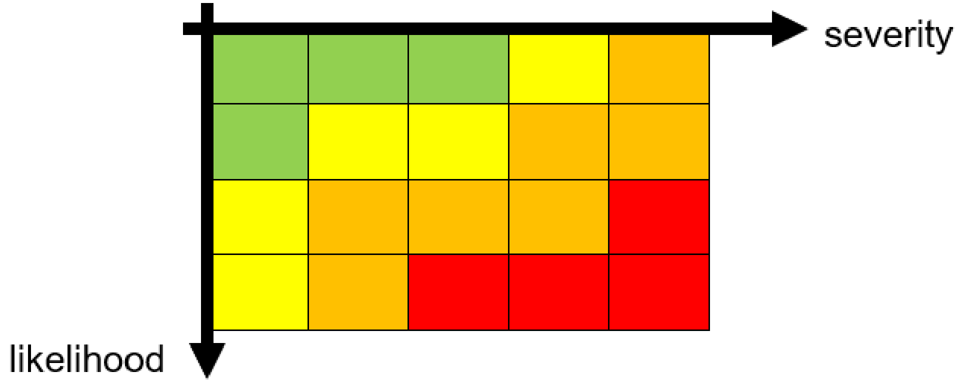
Abstract

A therapeutic medical physicist is responsible for reviewing radiation therapy treatment plans and patient charts, including initial treatment plans and new chart review, on treatment chart (weekly) review, and end of treatment chart review for both external beam radiation and brachytherapy. Task group report TG 275 examined this topic using a risk-based approach to provide a thorough analysis and guidance for best practice. Considering differences in resources and workflows of various clinical practice settings, the Professional Council of the American Association of Physicists in Medicine assembled this task group to develop a practice guideline on the same topic to provide a minimum standard that balances an appropriate level of safety and resource utilization. This medical physics practice guidelines (MPPG) thus provides a concise set of recommendations for medical physicists and other clinical staff regarding the review of treatment plans and patient charts while providing specific recommendations about who to be involved, and when/what to check in the chart review process. The recommendations, particularly those related to the initial plan review process, are critical for preventing errors and ensuring smooth clinical workflow. We believe that an effective review process for high-risk items should include multiple layers with collective efforts across the department. Therefore, in this report, we make specific recommendations for various roles beyond medical physicists. The recommendations of this MPPG have been reviewed and endorsed by the American Society of Radiologic Technologists and the American Association of Medical Dosimetrists.

KEYWORDS
MPPG 11.a, plan and chart review, safety and quality

Typical patient pathway external beam RT

- Clinical evaluation
- Therapeutic decision
- Patient set-up/immobilisation
- Motion management
- Imaging for planning
- Treatment planning
- Plan selection/QA
- Simulation
- Image guidance
- Treatment
- Evaluation during treatment
- Adaptation
- Follow up



Presented Platform : Global Alliance for Medical Physics Education and Research (GAMPER)

Typical patient pathway external beam RT

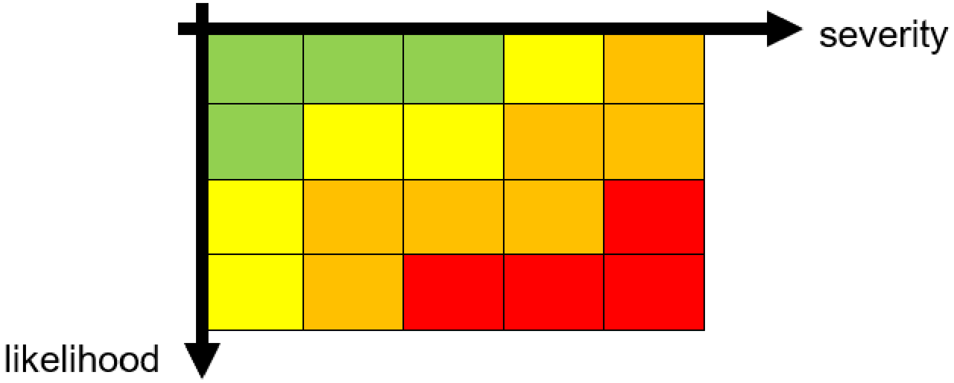
- Clinical evaluation
- Therapeutic decision
- Patient set-up/immobilisation — *Vendor 1*
- Motion management — *Vendor 1*
- Imaging for planning — *Vendor 2*
- Treatment planning — *Vendor 4*
- Plan selection/QA — *Vendor 5*
- Simulation
- Image guidance — *Vendor 6*
- Treatment — *Vendor 6*
- Evaluation during treatment
- Adaptation — *Vendor 6*
- Follow up

Vendor 3

PACS

Auto contouring

Vendor 4



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RADIATION ONCOLOGY PHYSICS

JOURNAL OF APPLIED CLINICAL MEDICAL PHYSICS

Frequency of errors in the transfer of treatment parameters from the treatment planning system to the oncology information system in a multi-vendor environment

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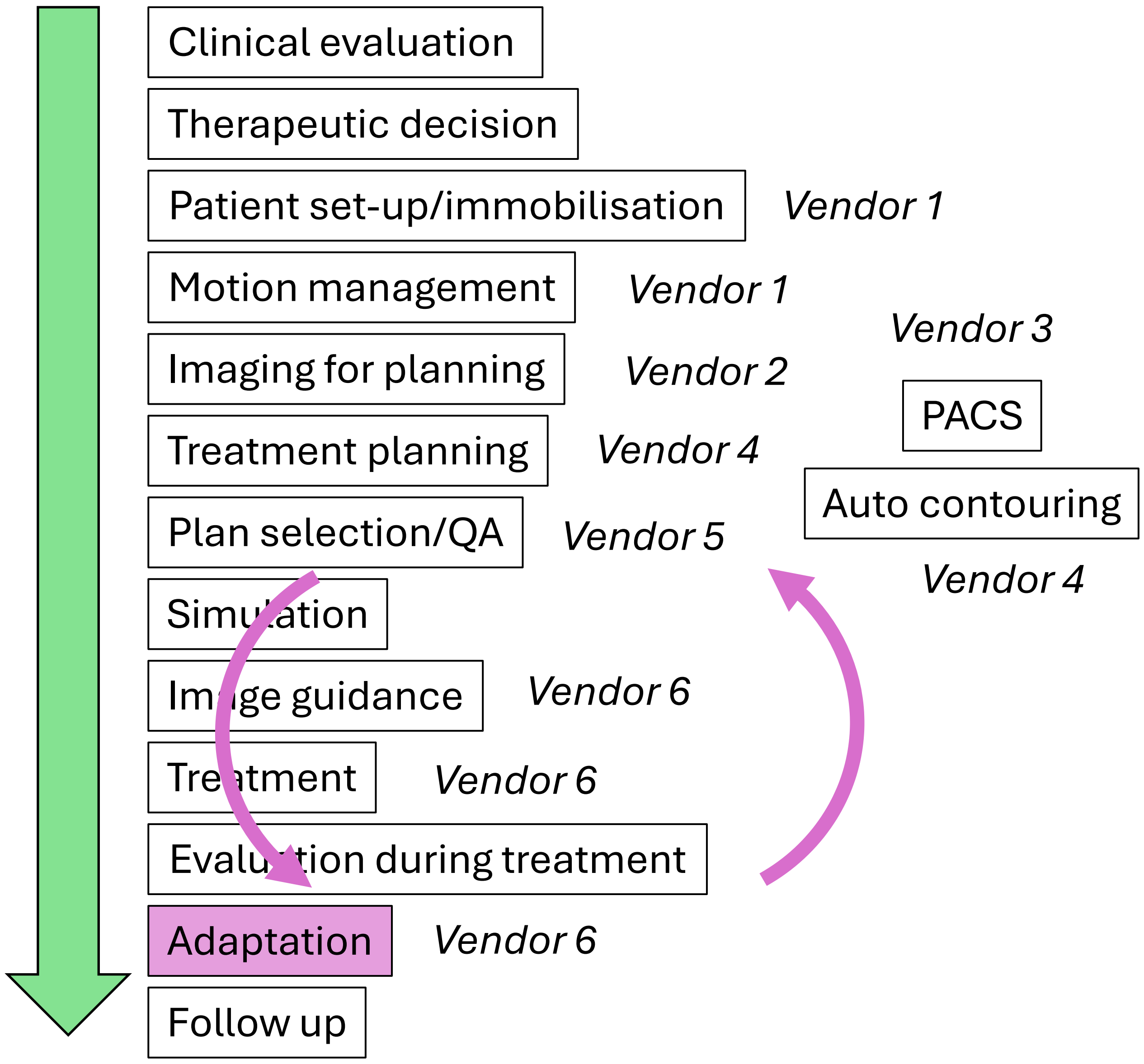
Abstract

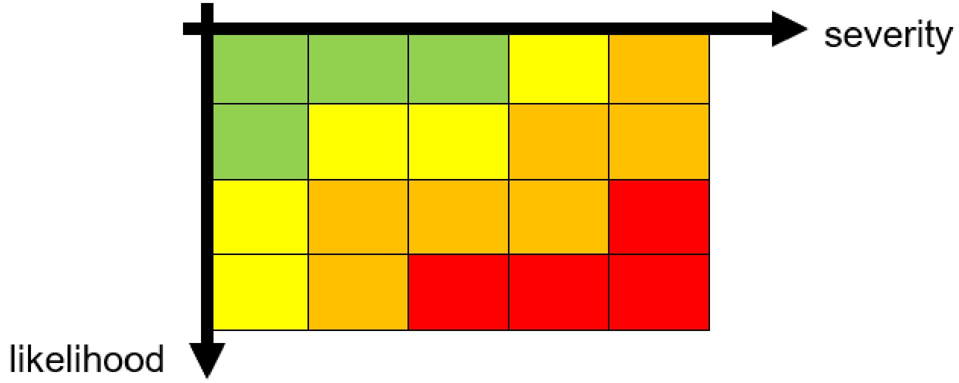
Background: Technological advancements have made it possible to improve patient outcomes in radiotherapy, sparing both normal tissues and increasing tumour control. However, these advancements have resulted in an increase in the number of software systems used, which each require data inputs to function. For institutions with multiple vendors for their treatment planning systems and oncology information systems, the transfer of data between them is potentially error prone and can lead to treatment errors.
Purpose: The goal of this work was to determine the frequency of errors in data transfers between the Varian Eclipse treatment planning system and the Elekta Mosaiq oncology information system.
Methods: An in-house program was used to quantify the number of errors for 2700 unique plans over an 8-month period. Using this information, the frequency of the errors were calculated. A risk priority number was calculated using the calculated frequencies to determine the impact on the clinic.
Results: The most common errors discovered were backup timer settings (10.7%), Field label (8.5%), DRR associations (3.3%), imaging field types (3.1%), dose rate (1%), Field Id (0.8%), imaging isocenter (0.7% and SSD (0.7%). Based on the risk priority numbers, the DRR association error was ranked as having the highest potential impact on the patient.
Conclusions: The results of the work show that the most effort should be focused on checking the manual steps performed in the transfer process, while items that are imported directly from DICOM-RT without modification are highly likely to be transferred accurately. The data can be used to help guide the implementation of future automated tools and process improvement in the clinic.

Own experience:

- Major issues related to multivendor environment
- CT issues mostly related to lasers and flat couch top

Typical patient pathway external beam RT





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Radiation Oncology

RESEARCH Open Access

Treatment plan quality during online adaptive re-planning

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Abstract

Background: Online adaptive radiotherapy is intended to prevent plan degradation caused by inter-fractional tumor volume and shape changes, but time limitations make online re-planning challenging. The aim of this study was to compare the quality of online-adapted plans to their respective reference treatment plans.

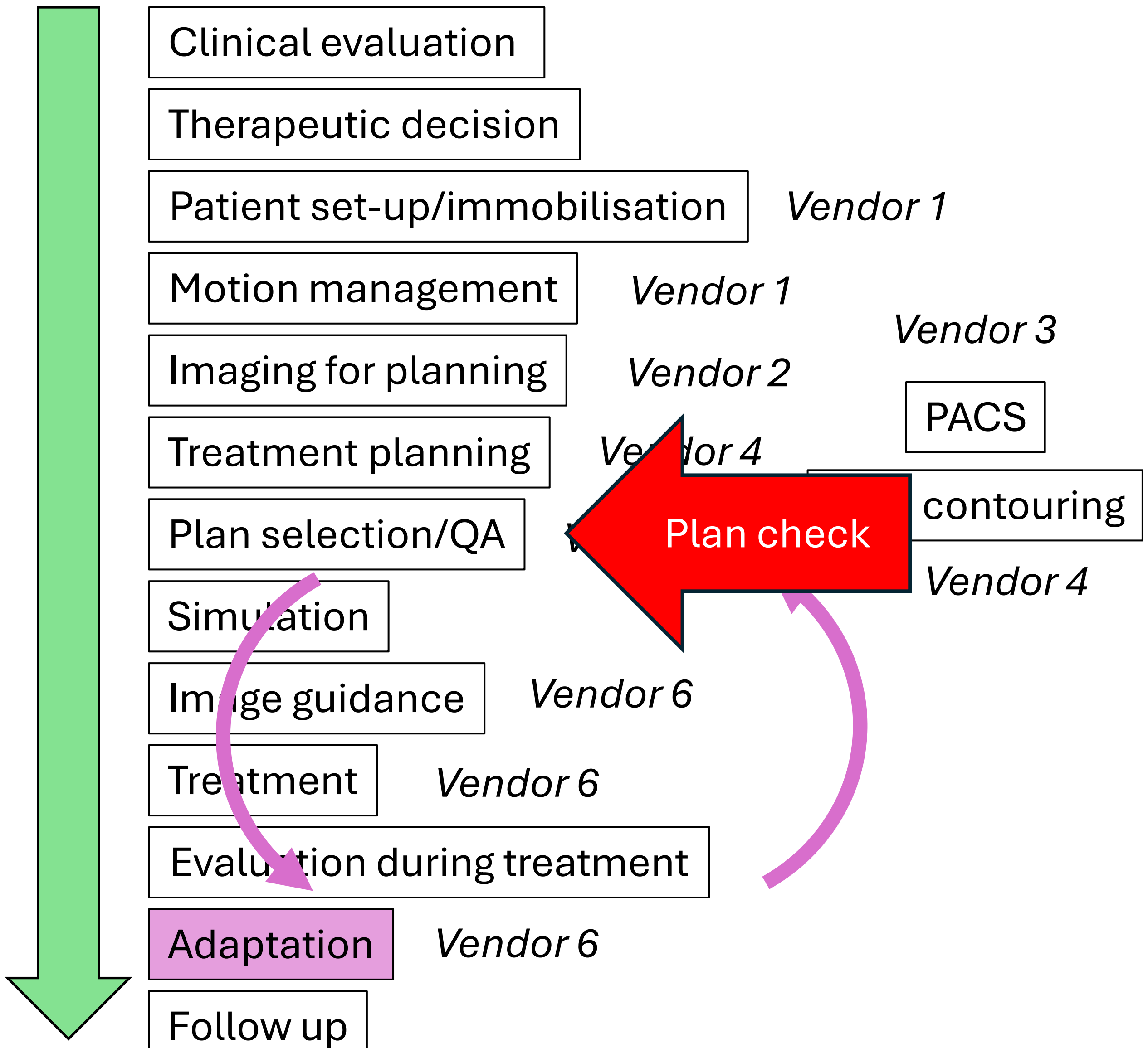
Methods: Fifty-two patients treated on a ViewRay MRIdian Linac were included in this retrospective study. In total 238 online-adapted plans were analyzed, which were optimized with either changing of the segment weights (n = 85) or full re-optimization (n = 153). Five different treatment sites were evaluated: prostate, abdomen, liver, lung and pelvis. Dosimetric parameters of gross tumor volume (GTV), planning target volume (PTV), 2 cm ring around the PTV and organs at risk (OARs) were considered. The Wilcoxon signed-rank test was used to assess differences between online-adapted and reference treatment plans, $p < 0.05$ was considered significant.

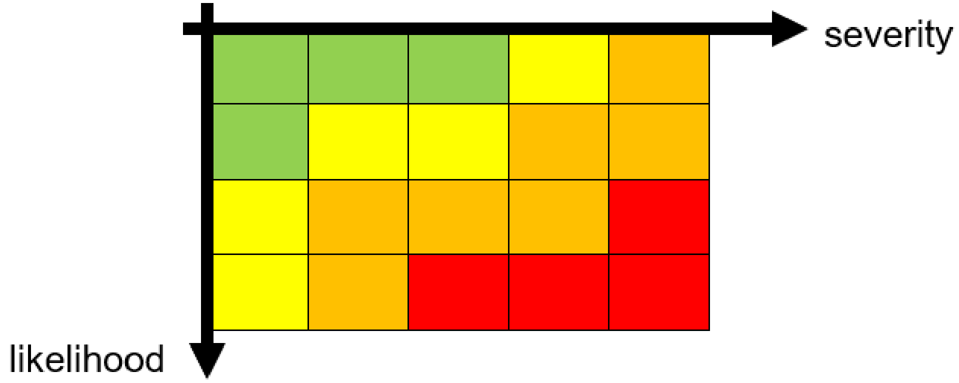
Results: The average duration of the online adaptation, consisting of contour editing, plan optimization and quality assurance (QA), was 24 ± 6 min. The GTV was slightly larger (average ± SD: 1.9% ± 9.0%) in the adapted plans than in the reference plans ($p < 0.001$). GTV-$D_{95\%}$ exhibited no significant changes when considering all plans, but GTV-$D_{2\%}$ increased by 0.40% ± 1.5% on average ($p < 0.001$). There was a very small yet significant decrease in GTV-coverage for the abdomen plans. The ring D_{mean} increased on average by 1.0% ± 3.6% considering all plans ($p < 0.001$). There was a significant reduction of the dose to the rectum of 4.7% ± 16% on average ($p < 0.001$) for prostate plans.

Conclusions: Dosimetric quality of online-adapted plans was comparable to reference treatment plans and OAR dose was either comparable or decreased, depending on treatment site. However, dose spillage was slightly increased.

Keywords: Radiotherapy, MR-linac, Online-adaptive radiation therapy, MR-guided, MRgRT, Online, Adaptive, Planning, SBRT

Typical patient pathway external beam RT





AI can help

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Automatic quality assurance of radiotherapy treatment plans using Bayesian networks: A multi-institutional study

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Conclusion: We have developed and validated a Bayesian network model to assist initial treatment plan review using multi-institutional data with different technology and clinical practices. The model has shown good performance even when trained on data from clinics with divergent profiles, suggesting that the model is able to adapt to different data distributions.

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Review Article

Overview of artificial intelligence-based applications in radiotherapy: Recommendations for implementation and quality assurance

Liesbeth Vandewinckele[a,b,1], Michaël Claessens[c,d,1], Anna Dinkla[e,1,*], Charlotte Brouwer[f], Wouter Crijns[a,b], Dirk Verellen[c,d], Wouter van Elmpt[g]

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ABSTRACT

Artificial Intelligence (AI) is currently being introduced into different domains, including medicine. Specifically in radiation oncology, machine learning models allow automation and optimization of the workflow. A lack of knowledge and interpretation of these AI models can hold back wide-spread and full deployment into clinical practice. To facilitate the integration of AI models in the radiotherapy workflow, generally applicable recommendations on implementation and quality assurance (QA) of AI models are presented. For commonly used applications in radiotherapy such as auto-segmentation, automated treatment planning and synthetic computed tomography (sCT) the basic concepts are discussed in depth. Emphasis is put on the commissioning, implementation and case-specific and routine QA of AI models needed for a methodical introduction in clinical practice.

Journal of Medical Radiation Sciences

Open Access

EDITORIAL

Artificial Intelligence and the future of radiotherapy planning: The Australian radiation therapists prepare to be ready

Vanessa Panettieri, PhD[1,2,3,4], & Giovanna Gagliardi, PhD[5,6]

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Automation at Peter Mac

- K Offer attempt to develop a machine learning model to predict plan QA results – problem not many ‘true fails’ in the training set

- For Plan Checks, we try and automate what we can
    - Automate ‘data entry’ recording
    - Automate report submission
    - Automate checking management
- We don’t try to automate what can’t
    - Human reasoning and oversight still important in the chain

Notifications

- Notifications each morning of new patient starts based on prescriptions and fields, not relying on having the task sent to us
- Saves time following things up, helps monitor incoming workload
- Aim to turn this into a live dashboard
- Also notifications for SABR scans at CT, new patients with implanted devices, patients who change UR while on treatment etc.

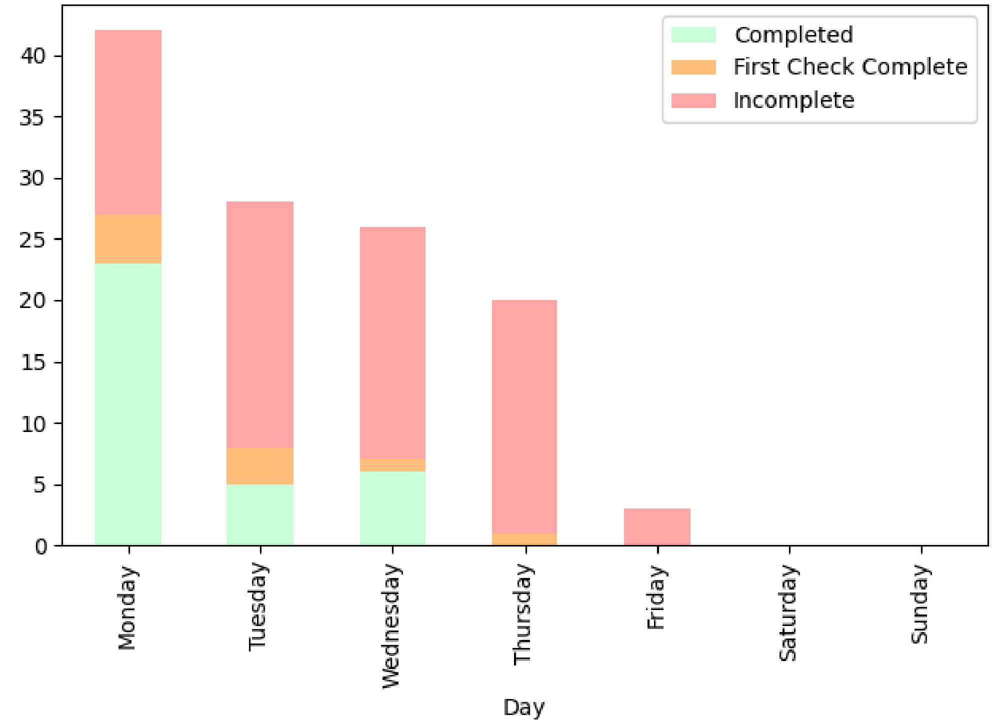
<-- This is an automated email -->

There may be some patients starting soon on one of BH2_TB, BH3_TB without plan checks, it might be worth checking the MOSAIQ schedule.

Today

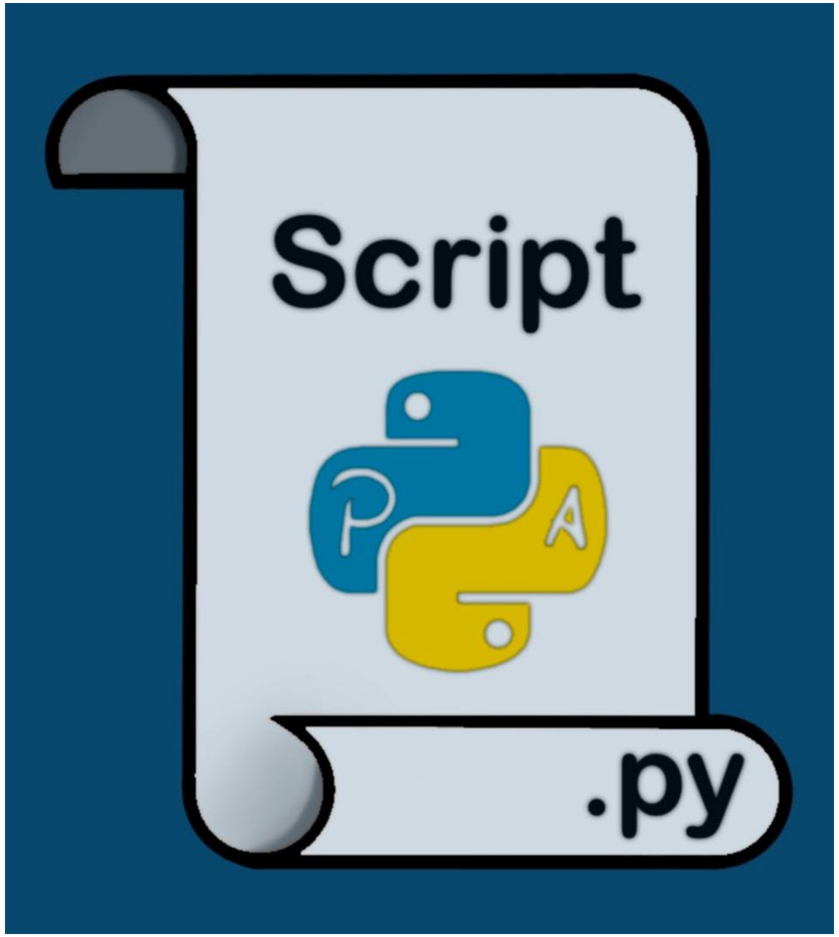
UR	Machine	Last Name	First Name	Possible Plan Name	Scheduled Time	Status	Info
[redacted]	BH3_TB	[redacted]	[redacted]	Rt BreastUFT	09:50:00	First Check Complete	Br IM/S, > (QA)
[redacted]	BH2_TB	[redacted]	[redacted]	None	10:40:00	Incomplete	Multi-Site (2), >> ?I/P BHH? TBC brain & Left Rib

Upcoming

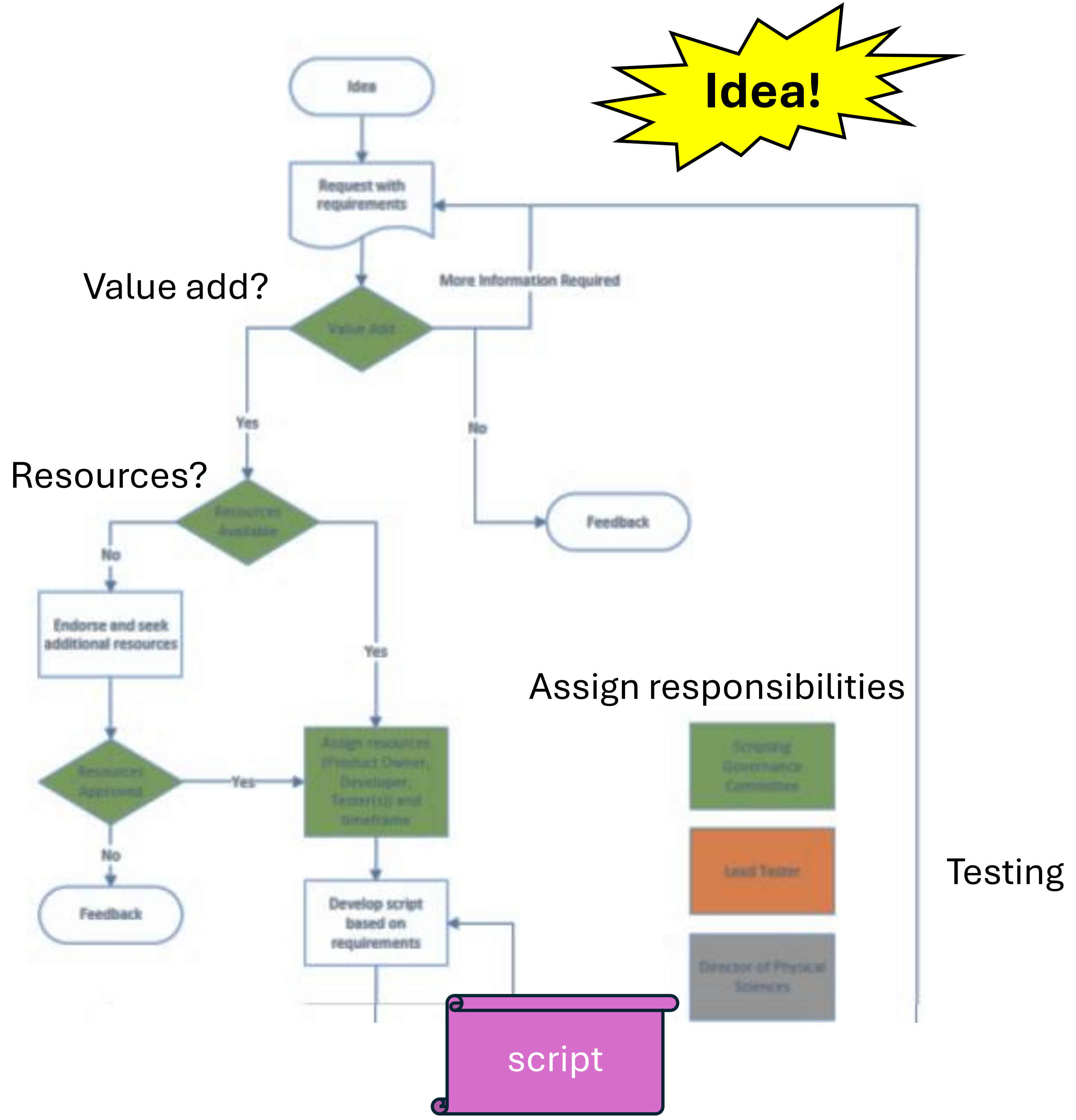


Scripting

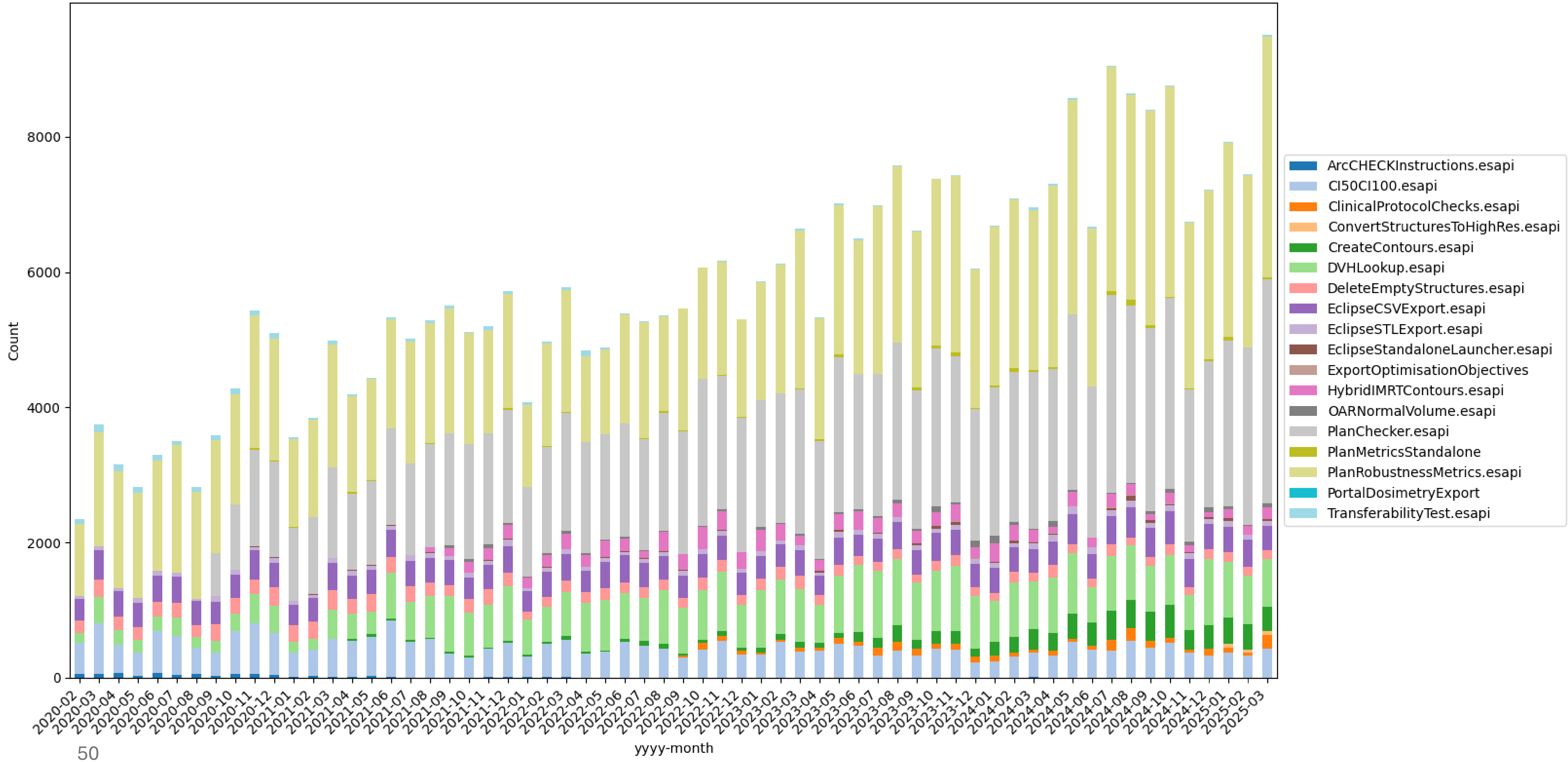
- Automation of otherwise manual processes
- Integral part of our treatment planning and plan checking practice



Governance and documented important

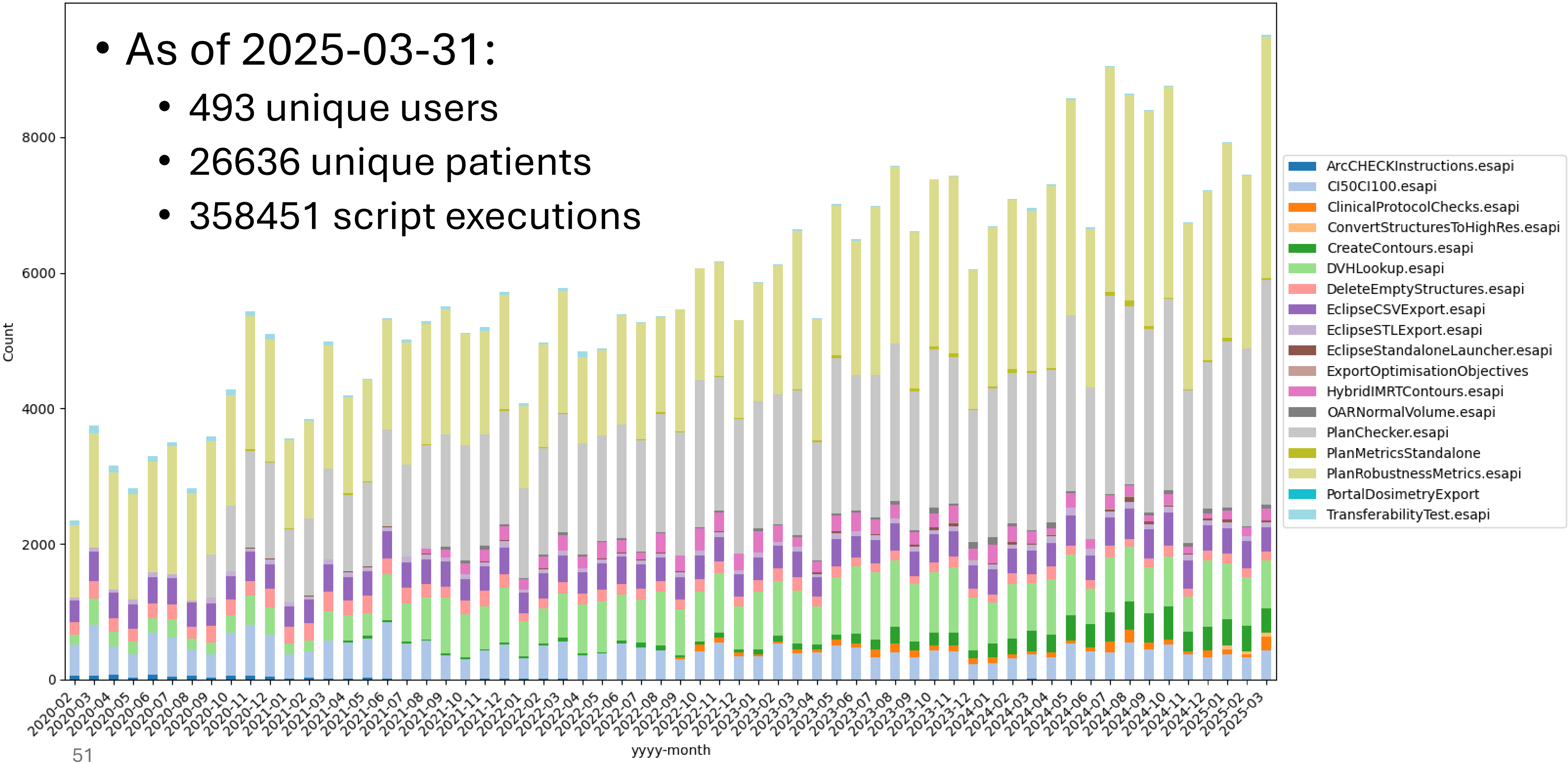


Peter Mac usage of Eclipse scripts

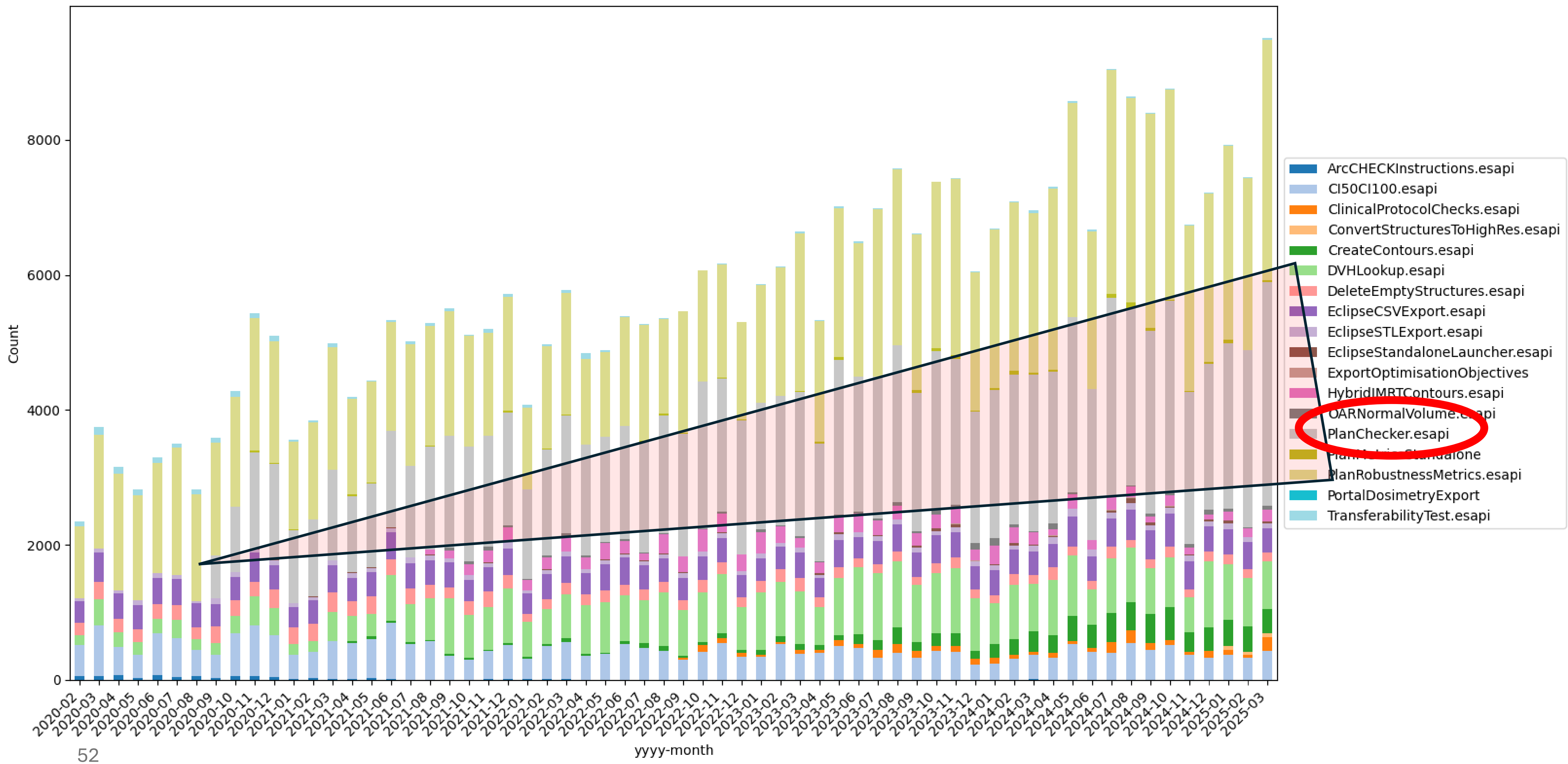


Peter Mac usage of Eclipse scripts

- As of 2025-03-31:
  - 493 unique users
  - 26636 unique patients
  - 358451 script executions



Peter Mac usage of Eclipse scripts



Plan check script

- Typically done prior to physics checks as part of planning
- Contains numerous elements from physics policies, e.g. hard rules:
    - Jaw tracking
    - Avoiding collimator 0
    - Dose and optimisation settings
    - High resolution structures
    - Slice thickness
    - Slice number (for third party systems)
    - Plan / treatment normalisation
- Various other issues that have caused issues in the past
    - Bolus not included in calculation
    - Common optimisation pitfalls
    - Couch correct for treatment unit
    - Incorrect dose rates
    - CT missing slices
    - Field ID's already in use on other plans
    - User origin moved
- Warn if not matching standarised naming
- And more

Does the plan check script work?

- Last time we ran the numbers, physics intervention rate reduced by approximately 1/3 for plans where the script was run

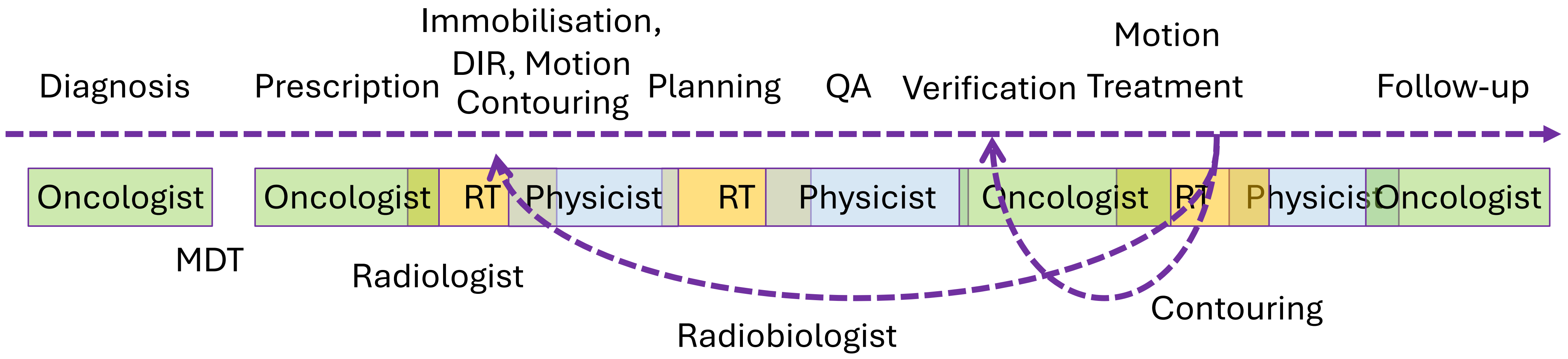
Traditional workflow

Diagnosis	Prescription	Planning	QA	Treatment	Follow-up
Oncologist	Oncologist	RT	Physicist	RT	Oncologist

Do we still need this?

?

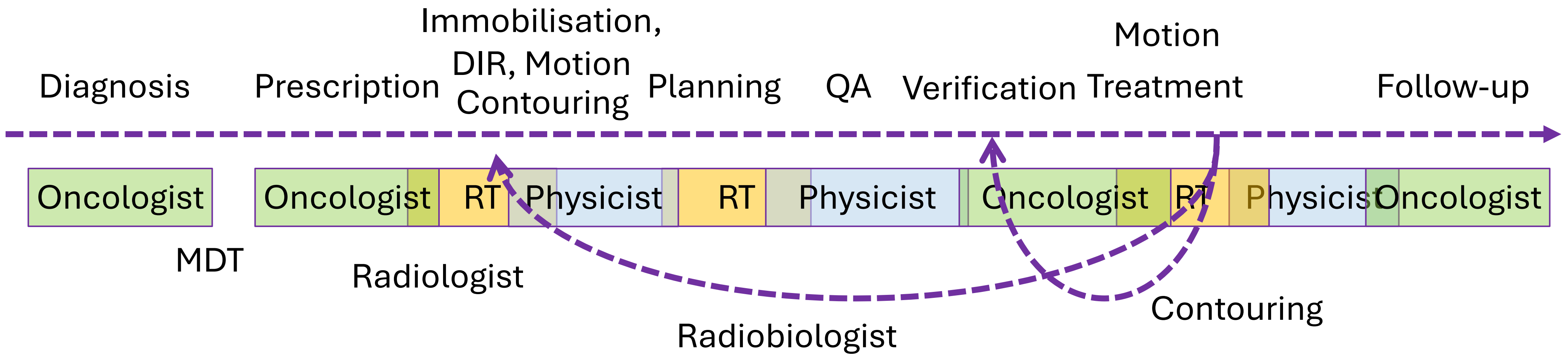
Advanced workflow (adaptive as an example)



Features:

- More professions
- More complex tasks
- Need for automation
- Overlap of tasks
- Non-linear workflows

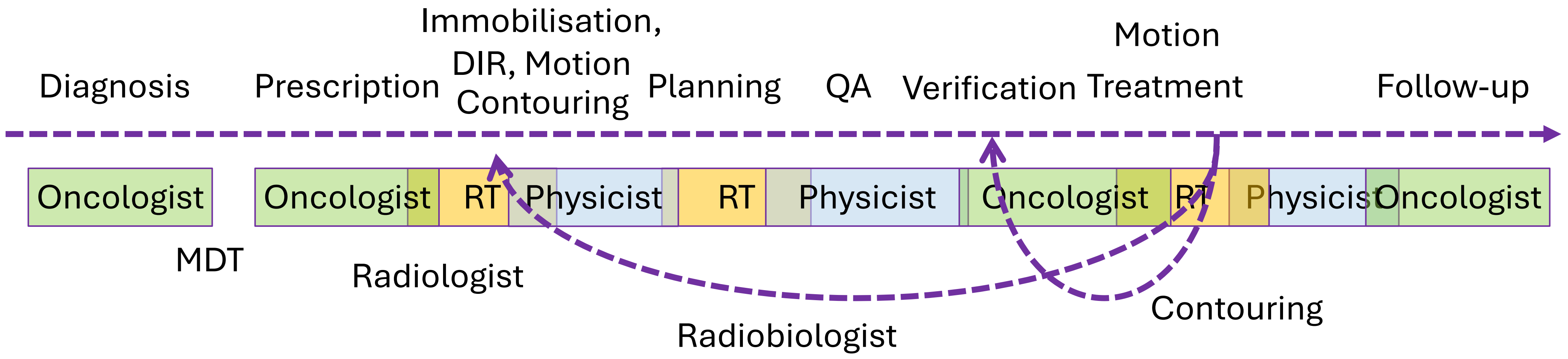
Advanced workflow (adaptive as an example)



Who checks what and when?

- Oncologist
- Radiation Therapist
- Physicist

Advanced workflow (adaptive as an example)



Who checks what and when?

- Oncologist
- Radiation Therapist
- Physicist

Some duplication is desirable:
Defence in Depth

What does the physicist bring to the table?

- Dose calculation algorithms
- Knowledge of imaging modalities
  - For planning
  - For IGRT
- 3D geometry
- Appreciation of motion
- Awareness of multivendor environment
- Good grasp of uncertainties
- Computer literacy

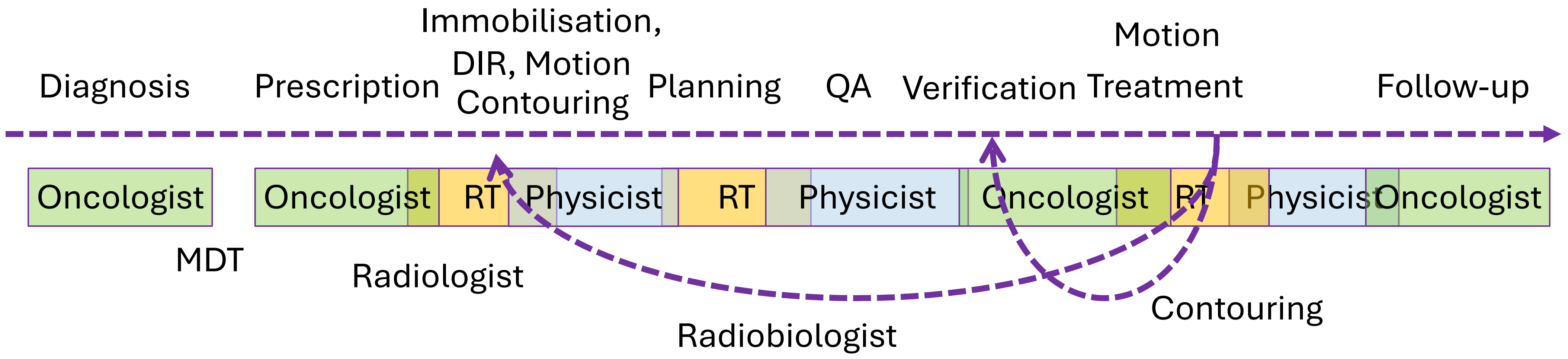
Role of plan checks

- Education of physicists
- Education of other professionals
- Ensuring a safe and deliverable plan for a patient
- Ensuring a close to optimal plan for a patient
- Providing feedback to the multidisciplinary team
- Learning for the next patient
- Improving planning process
- Informing future developments and purchases

Communication

Data base

Advanced workflow (adaptive as an example)



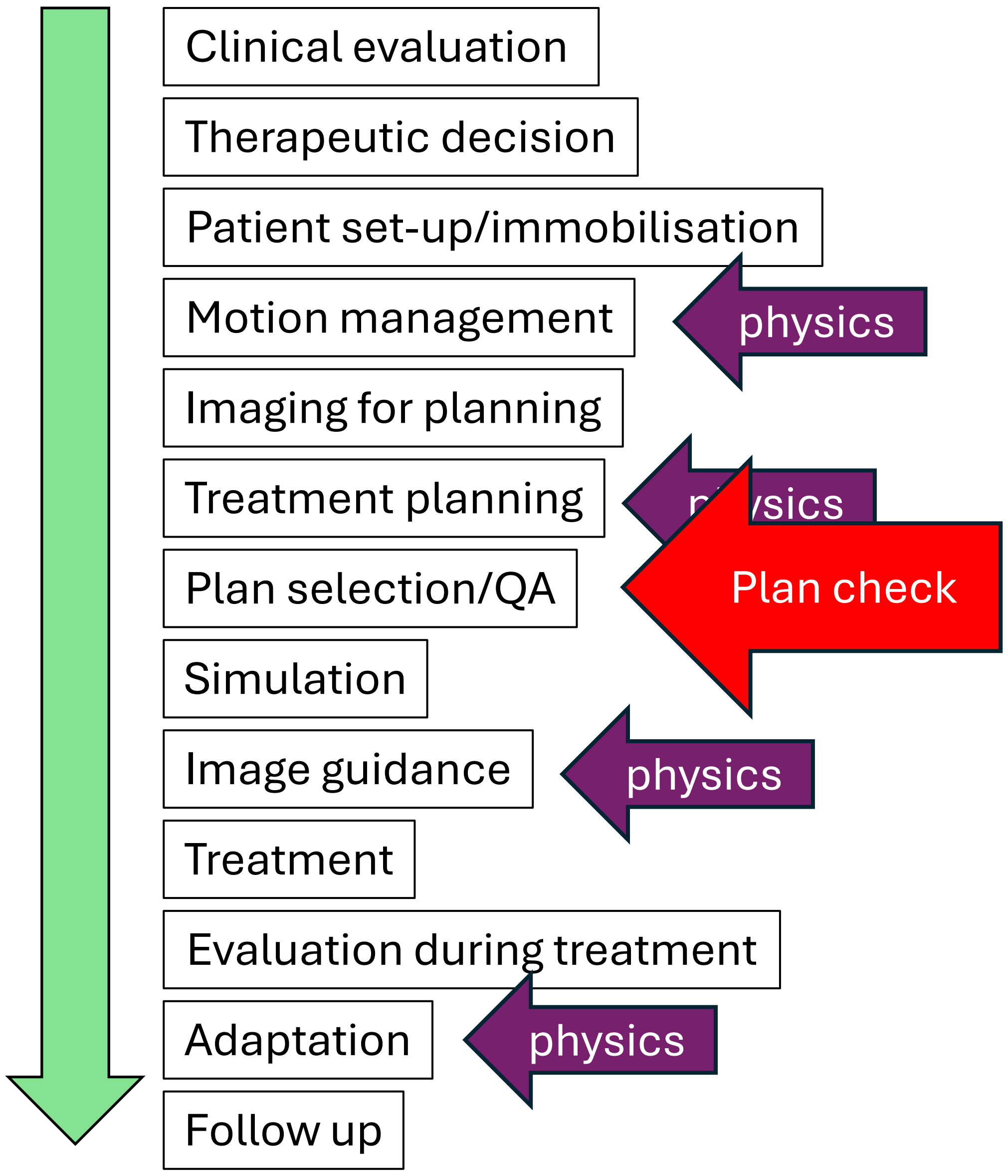
Who checks what and when?

- Oncologist
- Radiation Therapist
- Physicist

The last check?

- Least number of changes to be expected
- Least desire of anyone to implement a change

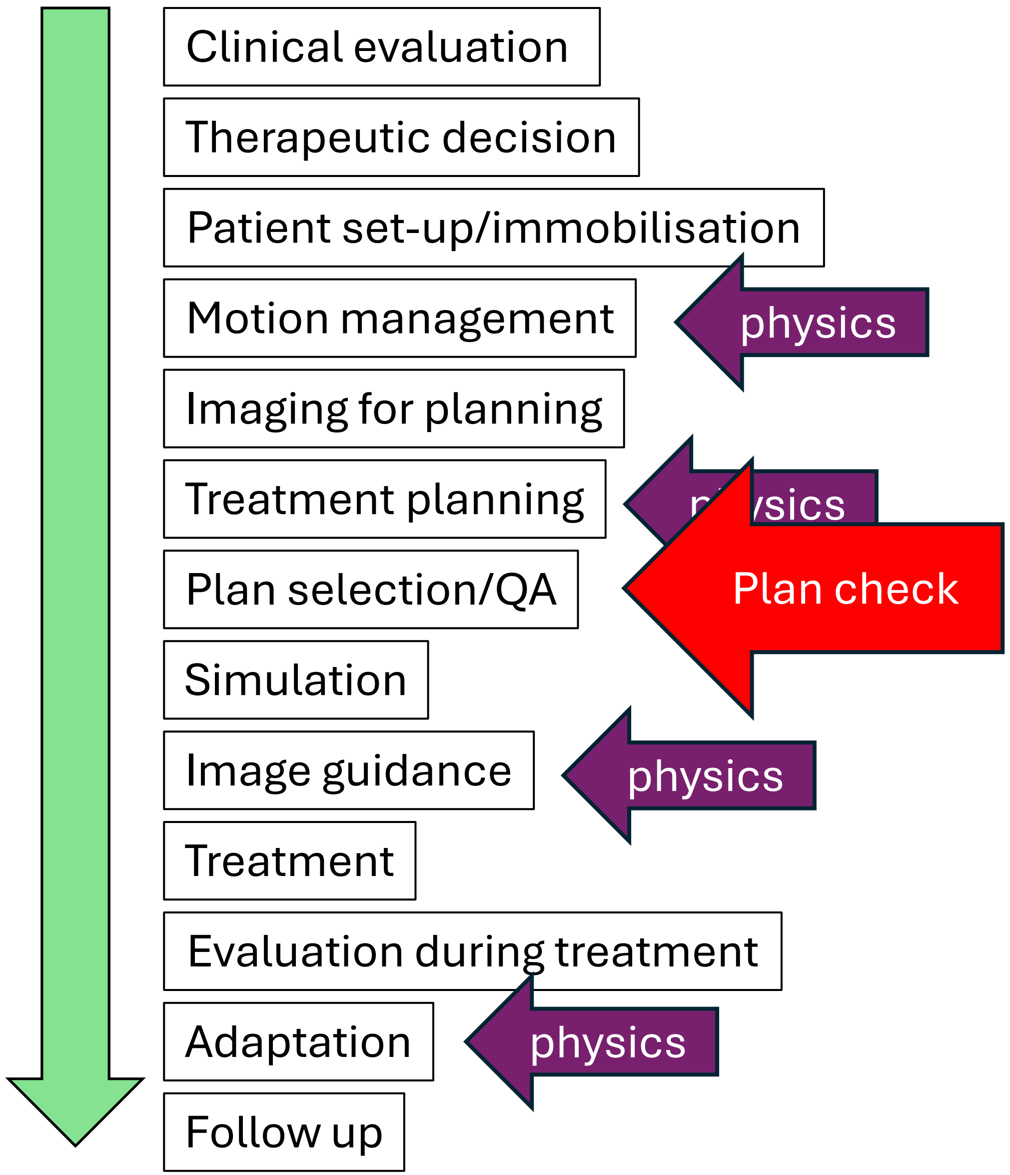
Typical patient pathway external beam RT



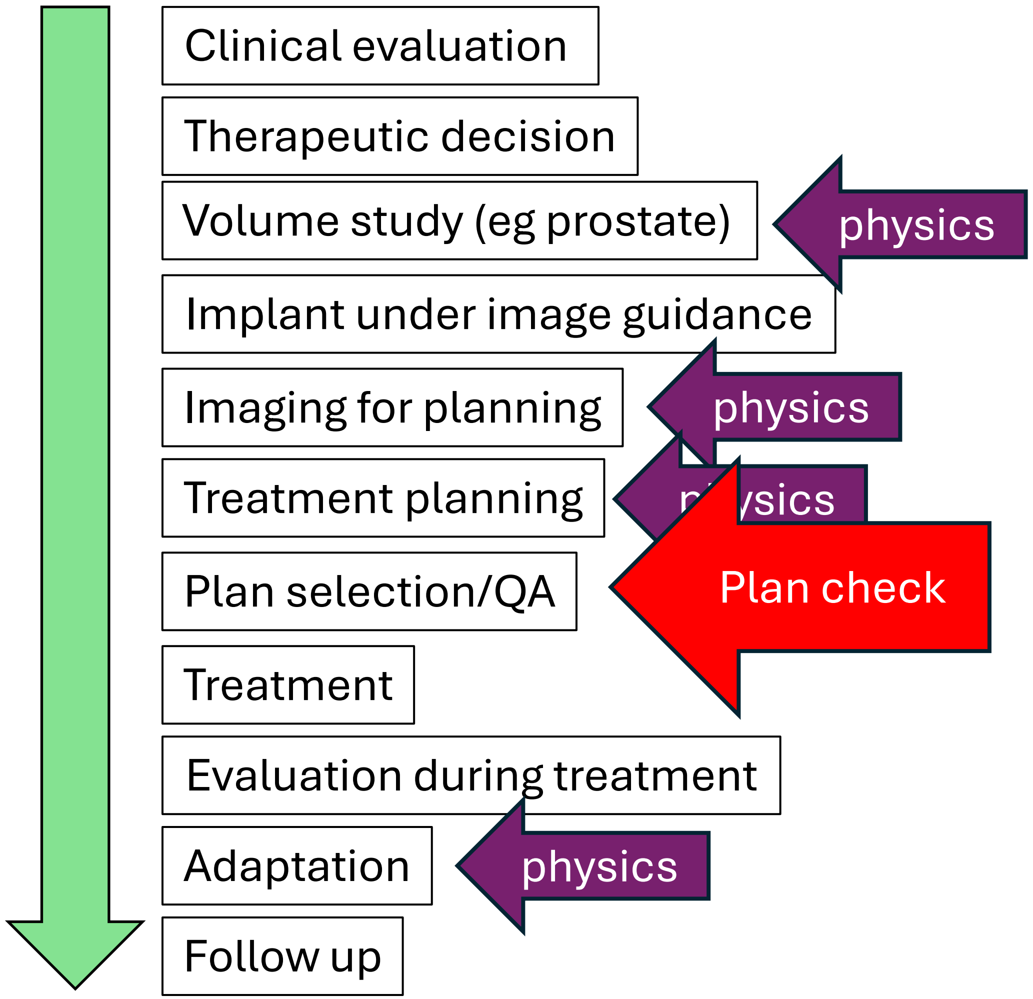
Summary

- Treatment plans are key documentation of radiotherapy
- Checking them is essential
- Deciding on the optimum checks and their schedule can be based on risk analysis
- Physicists bring a number of important qualities to the role
- Understanding of the clinical objectives is essential
- Automation will allow focus on new issues
- Once developed a process must evolve and can be adapted to other problems

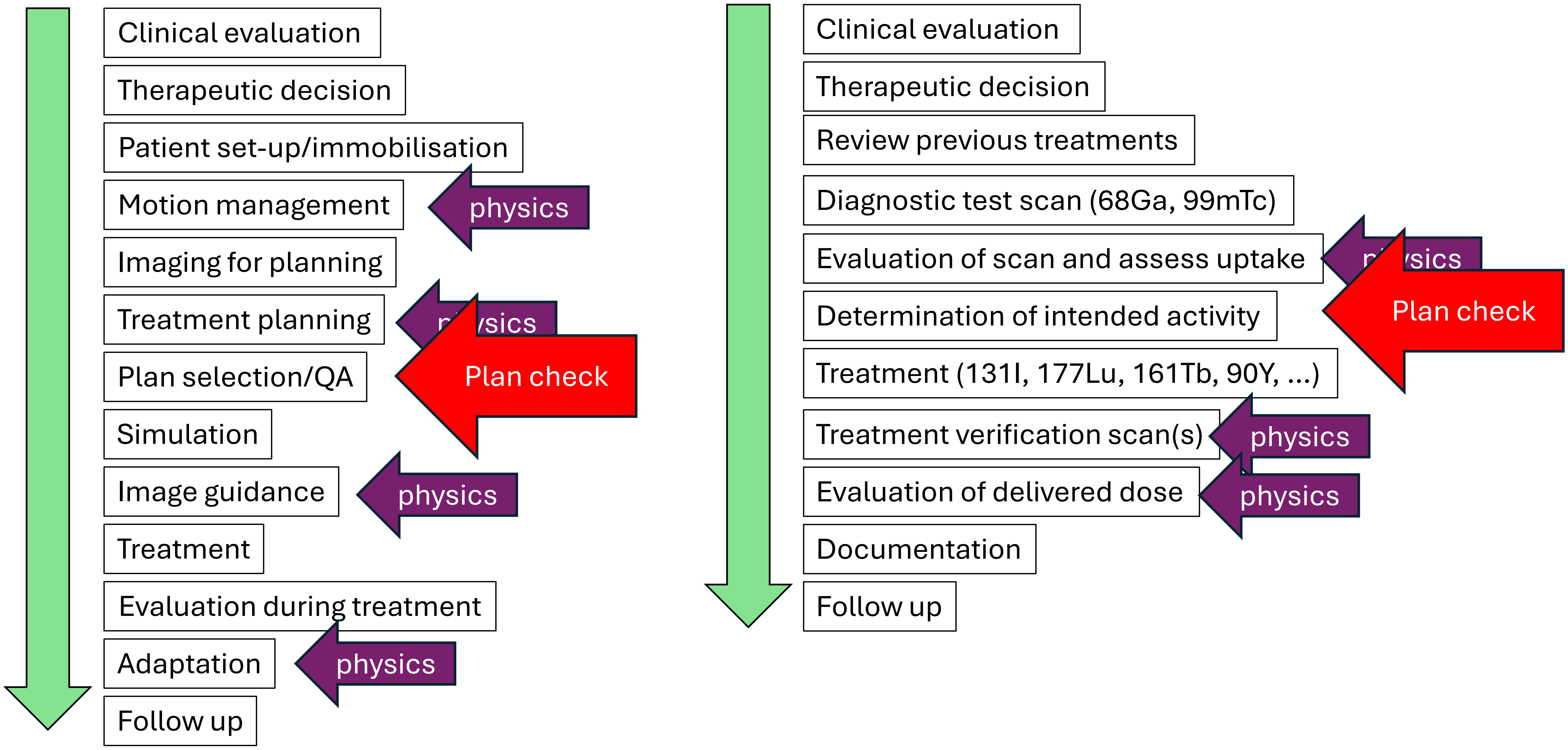
Typical patient pathway external beam RT



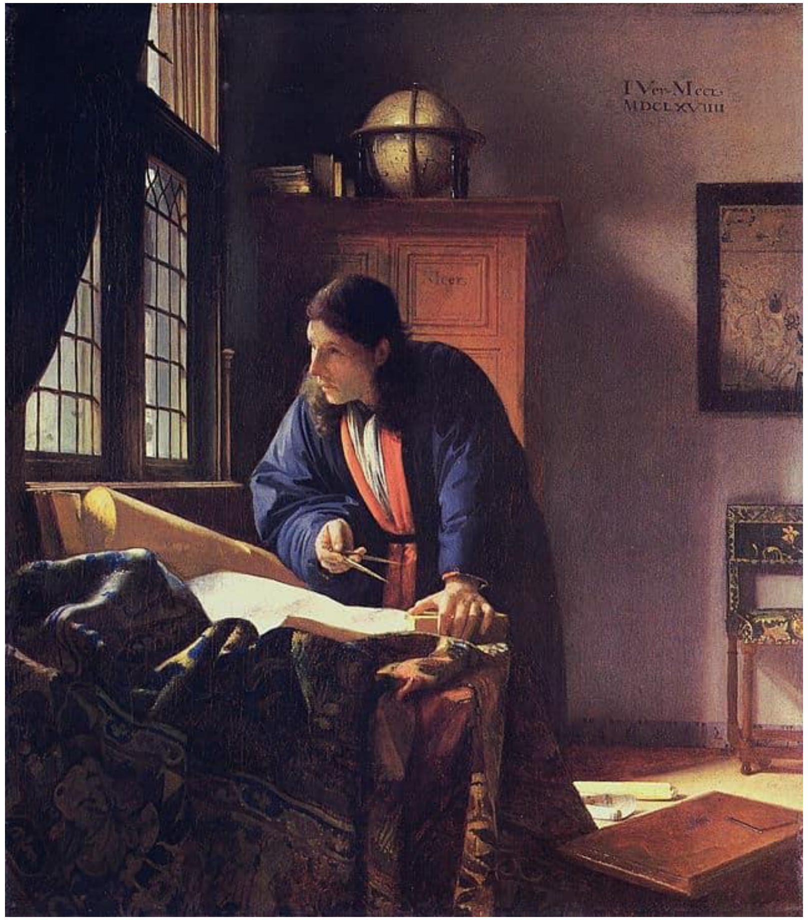
Typical patient pathway in brachytherapy



Typical patient pathway external beam RT | **Typical patient pathway in theranostics**



Thank you and many colleagues



Physicists checking plans

Presented Platform : Global Alliance for Medical Physics Education and Research (GAMPER)