

# Results of a Risk Management Program at Multiple Radiation Oncology Centers



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## Introduction

Safety performance and reliability in radiotherapy is worse than in other areas of medicine. We analyzed errors that were prospectively reported to an error reduction program in order to identify common error pathways. We examined where failures occurred, the overall error rates, and how our observed rates compared with others. The next step involved developing a prototype error reduction decision algorithm (called SoterRO) using sophisticated process control and machine learning. We quantified risk patterns and determined points of weakness in the entire treatment process including non-patient related QA and radiation safety areas.

## Materials & Methods

### Part I

- Our error reduction software program collected self-reported errors that were identified in the overall treatment process over 2 years at 3 different centers.
- Errors were defined as pre-treatment and post-treatment.
- Types of errors were selected from a hierarchy of folders that drilled down into 27 categories, 93 subcategories, 1,872 attributes, and unlimited custom attributes.
- Errors were then categorized, sorted, assigned a numerical assessment of risk (RPN), and corrected by root cause analysis.

### Part II

- A reference timeline of workflow using clinical pathways was created showing these categories and subcategories at levels 1 and 2, respectively (Fig. 2).
- Check points in the treatment process showed where and when clinical checks should occur in the workflow (Fig. 2).
- We built an error propagation model with flags and predictor variables using the ordered logit model (ordinal regression model).
- We measured what errors propagate undetected through 2 clinical check points designed to catch them.
- The prototype model determined points of weakness at different stages in the overall treatment process (Table 3).

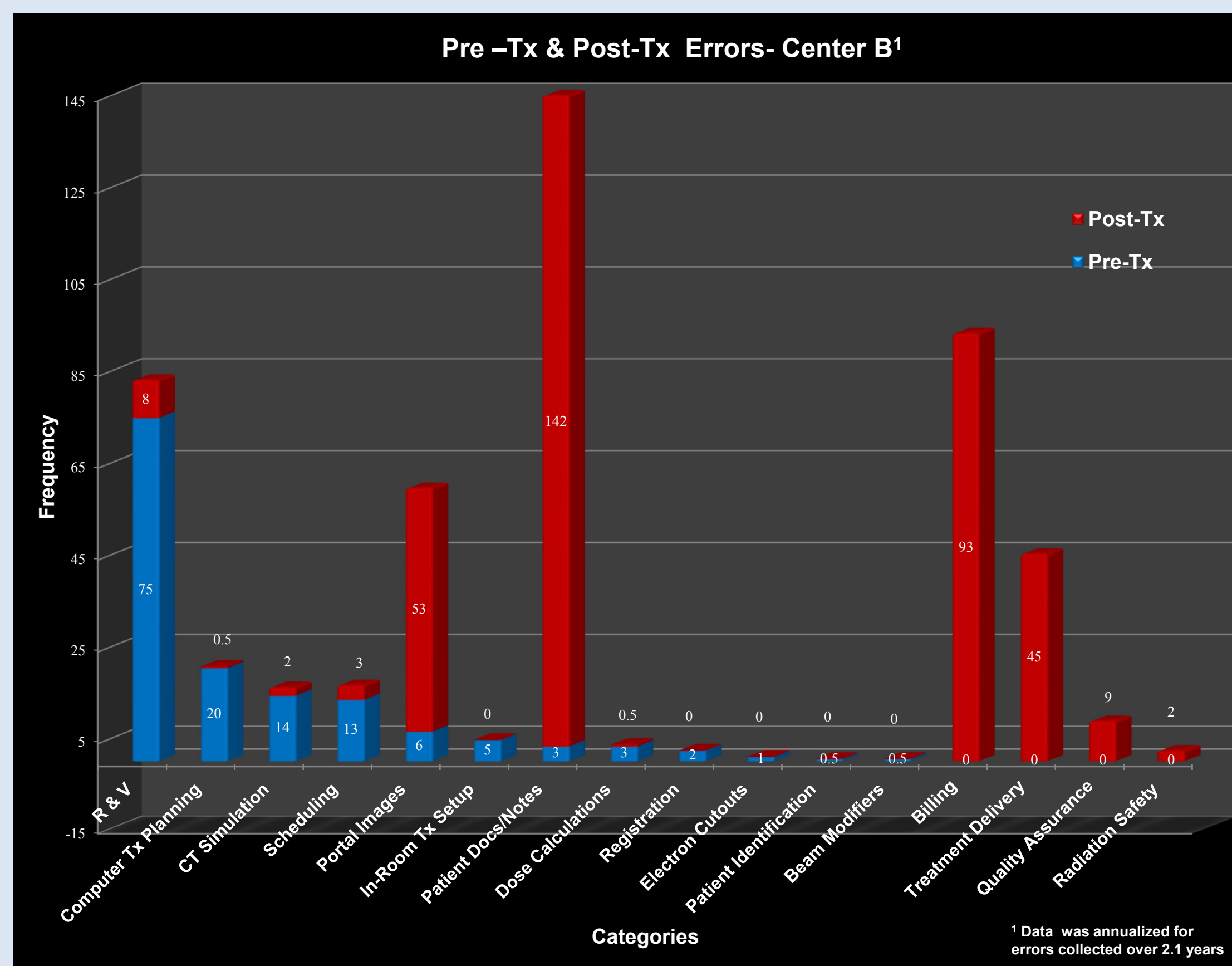
## Results

### Part I

Post-Tx error rates were higher than Pre-Tx error rates at all 3 centers (Table 1). Combined error rates showed most patients experienced some type of error that occurred from registration to completion of Tx. Center B errors highlighted documentation (Fig. 1). Error rates for treatment delivery varied from published rates (Table 2).

### Part II

Errors related to patient documentation/notes were very unlikely to be detected by either the 1<sup>st</sup> or 2<sup>nd</sup> check (Table 3). Similar patterns showed in Tx planning, imaging, and patient setup. On the other hand, errors related to patient registration or radiation safety were very likely to be detected within the first 2 checks.



Patient consults/notes, R&V data entry, billing, and imaging errors occurred most at Center B (Fig 1).

Error Category	Pre-Tx			Post-Tx			Pre-Tx + Post Tx		
	Center A	Center B	Center C	Center A	Center B	Center C	Center A	Center B	Center C
	115 errors	145 errors	66 errors	225 errors	362 errors	37 errors	340 errors	477 errors	103 errors
Per Patient, %	37.20	10.10	61.01	72.80	25.40	77.85	81.8	27.33	98.91
Per Fraction, %	1.10	0.34	1.73	2.10	0.85	2.20	2.40	0.92	2.80
Per Field, %	0.14	0.004	0.11	0.28	0.009	0.14	0.31	0.01	0.17

<sup>a</sup>Data for Centers A, B, and C was annualized for all pre-Tx and post-Tx errors (all aspects of the treatment process from registration to completion of treatment). Does not include QA, RS, or billing errors.

Error Category	This Work Center A	This Work Center B	This Work Center C	Ford et al.	Frass et al.	French et al.	Howell et al.	Huang et al.	Kline et al.	Marks et al.	Macklis et al.	Patton et al.	Margalit et al.
Per Patient, %	0.32	3.20	4.21	0.17			0.04 - 4.7	1.97		1.2 - 4.7			
Per Fraction, %	0.01	0.11	0.12		0.44	0.32		0.29		0.5			
Per Field, %	0.001	0.001	0.007		0.13	0.037 (0.17)					0.18	0.17	0.064
Overall Per Field, %	0.28 <sup>c</sup>	0.009 <sup>c</sup>	0.17 <sup>c</sup>			0.13 <sup>d</sup>			0.05 <sup>e</sup>				

<sup>a</sup>Treatment delivery means the administration of radiation to a patient. <sup>b</sup>Data for Centers A, B, and C was annualized. <sup>c</sup>Comprises the entire treatment process (excluding QA, RS, and Billing). <sup>d</sup>Errors per Tx units. <sup>e</sup>Errors per field in the entire post-Tx delivery process (from initial patient consultation to completion of Tx).

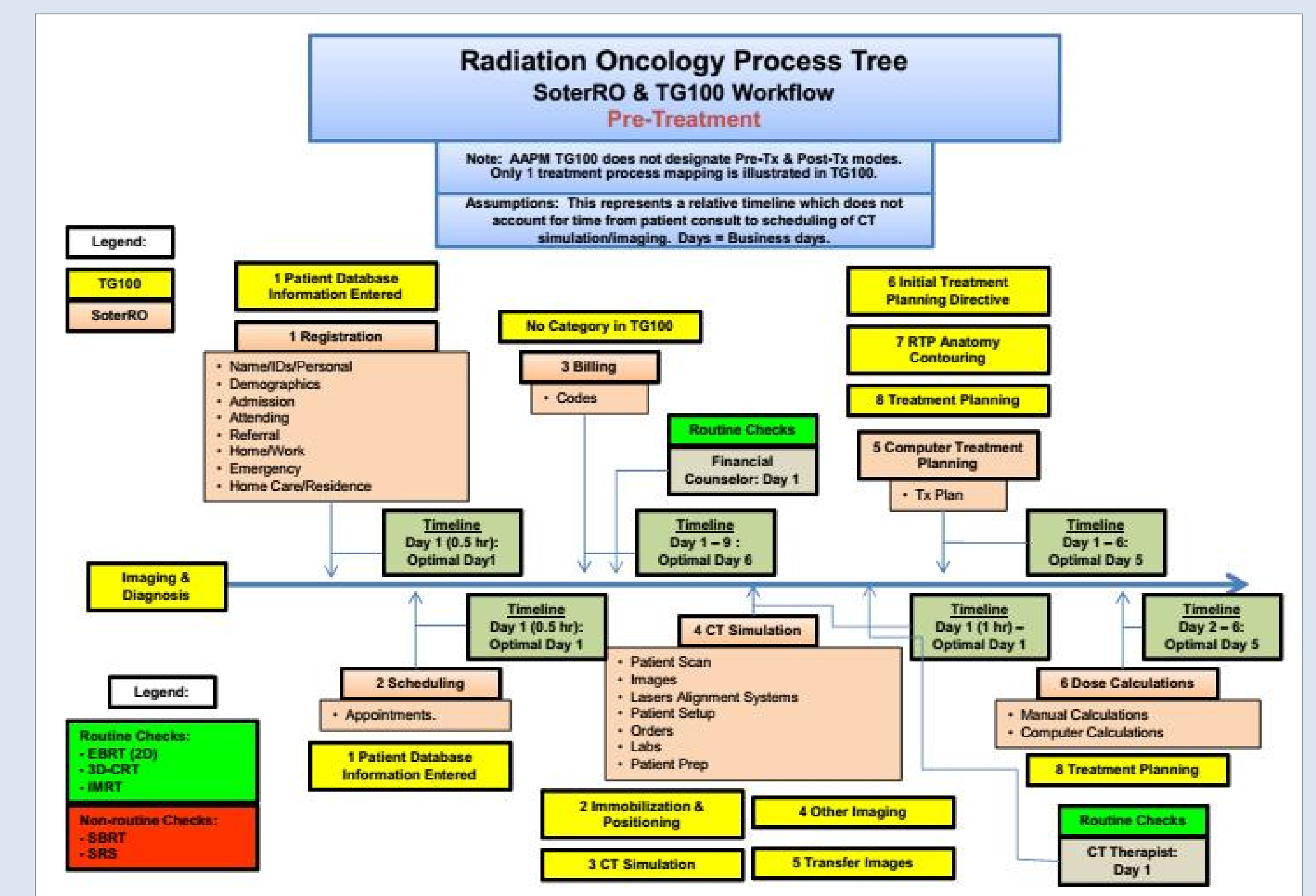


Figure 2

Table 3: Results for Level-1 Model

Level-1 Category	Center B		
	Check 1	Check 2	Neither
Patient Documents/Notes	2.4%	9.6%	88.0%
CT Simulation (Orders)	5.5%	19.0%	75.5%
Quality Assurance	5.7%	19.5%	74.8%
Scheduling (Appointments)	36.0%	39.8%	24.2%
Registration	80.8%	15.1%	4.1%
Radiation Safety (Reviews)	100.0%	0.0%	0.0%
Computer Tx Planning	2.3%	9.3%	88.4%
Dose Calculations	5.3%	18.4%	76.3%
Billing (Codes)	6.9%	22.2%	70.9%
R & V (Treatment Field Definitions)	0.0%	0.0%	100.0%
R & V (Tx Plan)	1.0%	4.5%	94.5%
Electronic Images	2.1%	8.7%	89.2%
Treatment Delivery	3.0%	11.8%	85.2%
In-Room Tx Setup	6.5%	21.5%	72.0%
Misc Level1	16.4%	35.8%	47.8%

## Conclusion

Most patients experienced an error of some type in their treatment pathways. Our prototype SoterRO program can objectively, efficiently, and effectively determine points of weakness in the care continuum of radiotherapy. We can now ingest far more data quickly with additional insights and fast results. We validated the algorithm to allow for predictive analytics of high-risk feature combinations in the future.