Optimizing Efficiency and Safety in External Beam Radiotherapy using Automated Plan Check (APC) Script and Six Sigma Methodology

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Background
- As the majority of errors in radiotherapy originate in treatment planning, the physics plan check was found to be the most effective individual quality control step in the radiotherapy workflow3.
- However, its sensitivity to identify a defect is still low2.
- As technological advances can make manual verification of treatment plans increasingly challenging, automation and computerization can offer greater effectiveness thereby potentially enhancing safety4.

Objectives/Aims
- In this work, aimed at reducing errors stemming from treatment planning, we applied the Six Sigma Define-Measure-Analyze-Improve-Control (DMAIC) methodology to develop and implement an Automated Plan Check (APC) tool using Eclipse Scripting Application Programming Interface (ESAPI).

Methods
- The Six Sigma Define-Measure-Analyze-Improve-Control (DMAIC) framework was used by measuring defects stemming from treatment planning that were reported to the departmental incidence learning system (ILS), Figure 1.
- The common error pathways observed in the reported data were combined with our departmental physics plan check list, and AAPM TG-275 identified items.
- Prioritized by Risk Priority Number (RPN) and severity values, the check items were added to the APC tool developed using Varian ESAPI.
- At 9 months post-APC implementation, the tool encompassed 89 check items, and its effectiveness was evaluated by comparing RPN values and rates of reported errors.
- To test the efficiency gains, physics plan check time and reported error rate were prospectively compared for 20 treatment plans.

Results
- The APC tool was successfully implemented for external beam plan checking, Figure 2.
- Failure Modes and Effects Analysis (FMEA) RPN ranking re-evaluation at 9 months post-APC demonstrated a statistically significant average decrease in RPN values from 129.2 to 83.7 (p = 0.05), Figure 3.
- The process shifted from 4 to 5 quality for isocenter-shift errors.

Limitations
- Only 41.6% of plan check items identified by FMEA were suitable for either full or partial automation within the ESAPI environment.
- Incidence reporting cannot be assumed to be consistent throughout the time period or complete.
- The environment is certainly not controlled as policies and procedures get introduced. We would like to note though that addition of 4 new dosimetrists (40%) to the team during the post-APC phase still resulted in decrease in errors compared to pre-APC phase.
- In addition to the above uncertainties, the FMEA is a semiquantitative analysis and is highly dependent on the users’ assessment of the risk factors and their impact in the clinic.

Conclusions
- Incorporation of APC tool has significantly reduced the error rate. The DMAIC framework can provide an iterative and robust workflow to improve the efficiency and quality of treatment planning procedure enabling a safer radiotherapy process.

Future Directions
- A logical next step in improvement is converting APC checks into forcing the user to correct the errors, not merely detecting them.
- In addition, apart from rule-based automated checking approaches, knowledge-based automated QA/QC methods have recently shown great potential in decision-making in radiotherapy. They can be applied to detect outliers, raise warnings on suboptimal plans, ensure optimal dose prescription and treatment plan quality, and to predict treatment outcomes.

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Acknowledgments: We would like to acknowledge our dosimetry team and radiation oncologists in diligently reporting errors. Continuing the use of the APC tool and constantly providing feedback for its improvement.

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