Math meets the Clinic: Modeling Patient Specific

HNSCC Radiation Response Dynamics

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Background

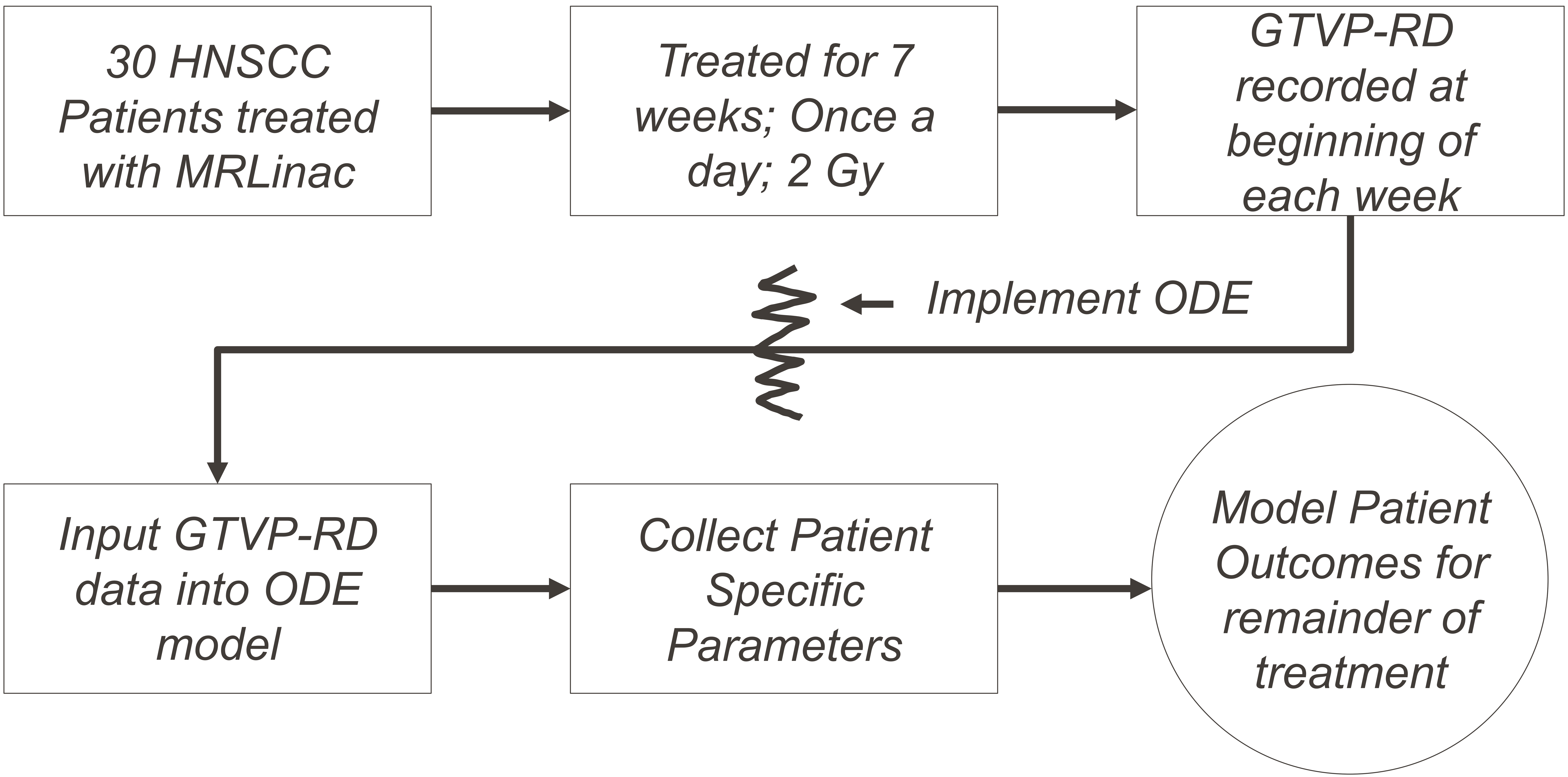
Head and neck squamous cell carcinomas (HNSCCs) arise from the mucosal lining of the upper aerodigestive tract and are also the most common cancer type in this region [1]. Within this subtype of cancer, radiation therapy has become a crucial cornerstone in developing standard of care for these patients [2]. Radiation as a therapeutic intervention possesses unique dynamics that may lead to disparities in outcomes and in the biological response on both the tumor and normal tissues [3, 4].

The Problem

Despite the advancements in radiation therapy for HNSCCs, a significant challenge remains in predicting individual patient responses during the course of treatment. The variability in how patients respond to radiation poses difficulties in optimizing therapy, often leading to under/over-treatment and possibly adverse effects [2]. Because there is no biomarker, this underscores the need for reliable predictive measures that can guide clinical decisions in real-time [3, 4].

Our Approach

Methods: Dataset Implementation

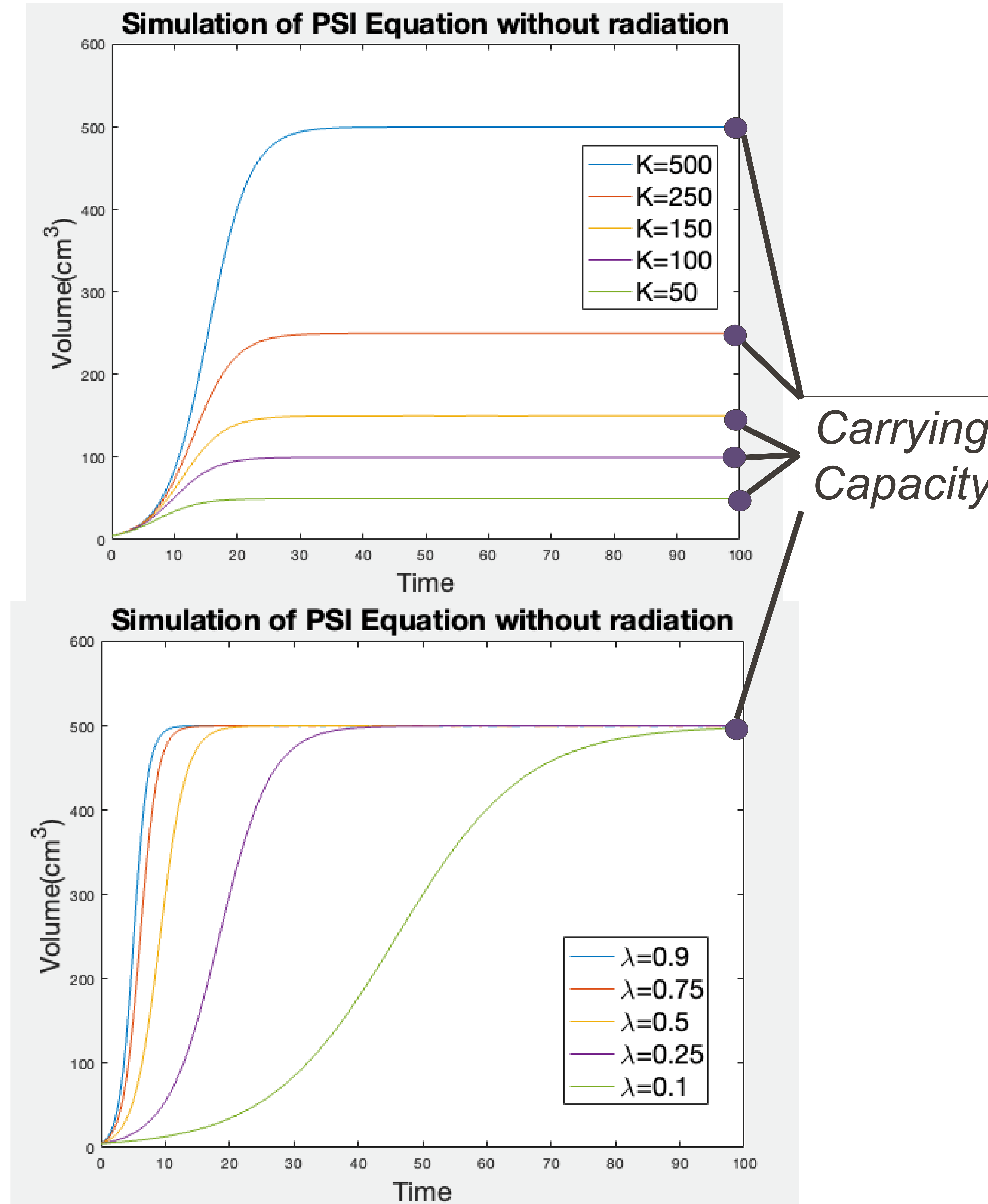


Methods: Models

We introduce a model that determine tumor volume(V(t)) at a certain time(t) :

$$\frac{dV}{dt} = \lambda * V * \left(1 - \frac{V}{K}\right)$$

λ represents the intrinsic growth rate of the tumor(day $^{-1}$)
K represents the carrying capacity(cm^3)

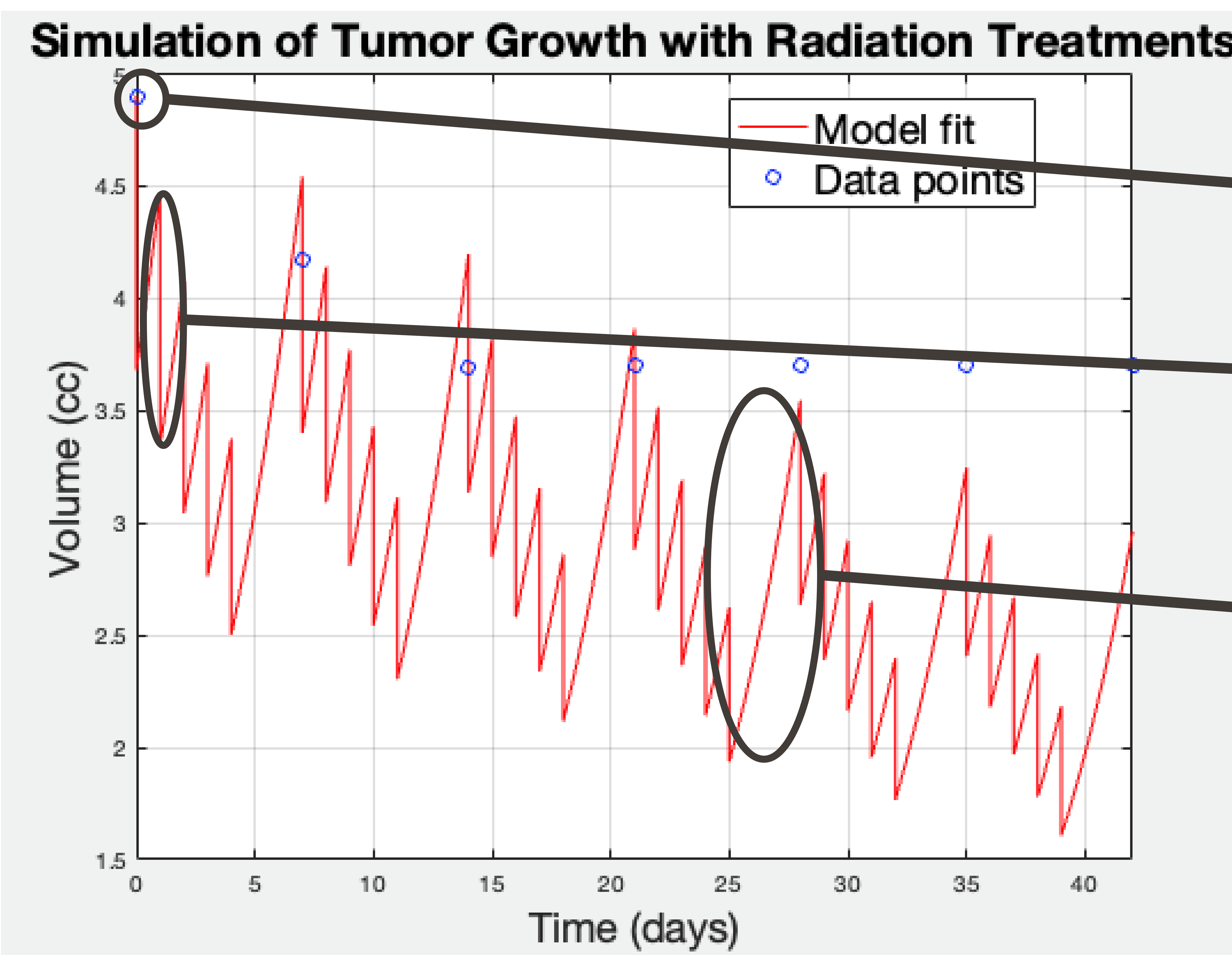


Methods: Models cont.

We introduce a reduction equation to model radiation response:

$$V_{postRT} = Vp_{reRT} - \gamma_d * Vpr_{eRT}\left(1 - \frac{V}{K}\right)$$

γ_d *represents the radiation induced death*

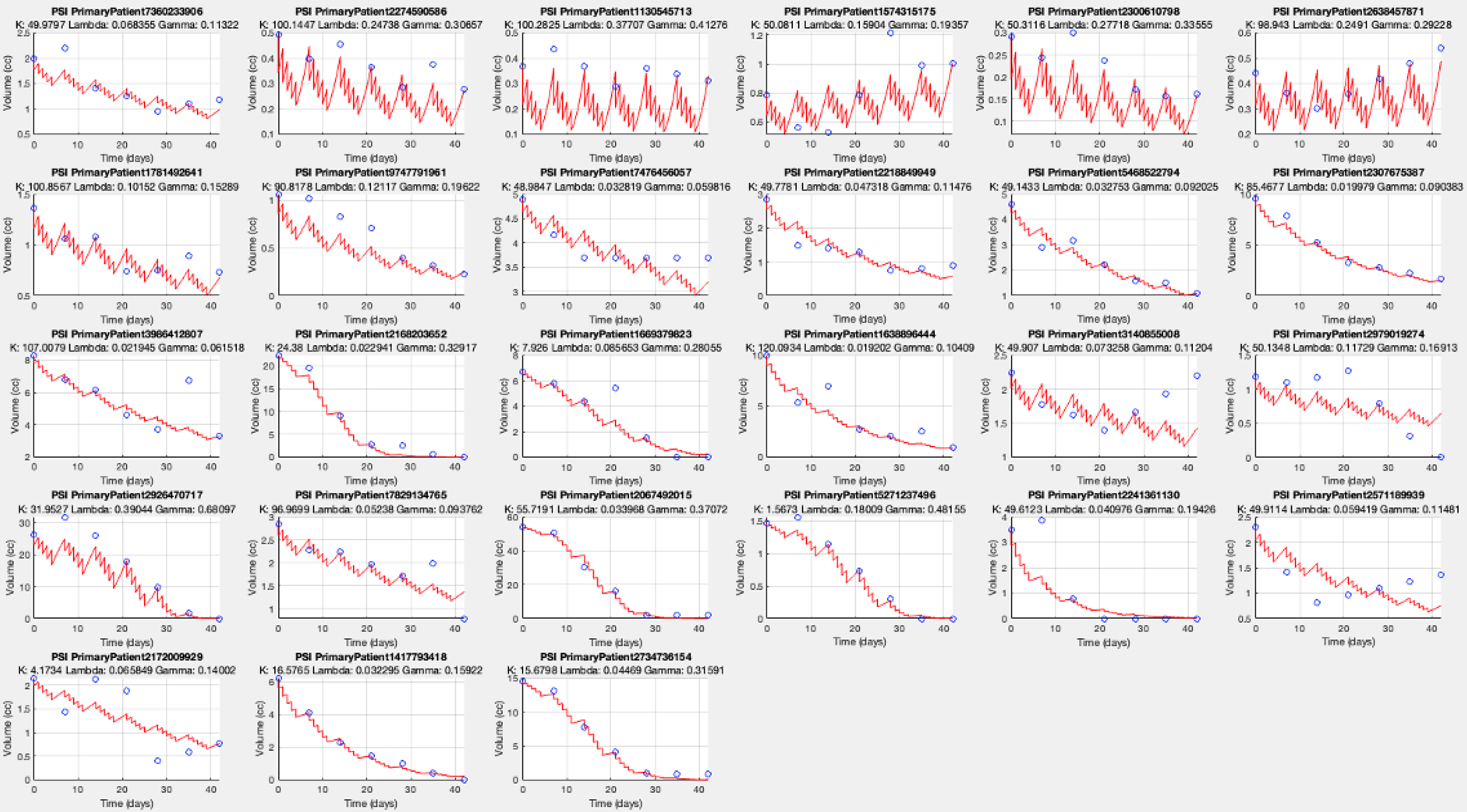


Proliferation Saturation Index: $PSI = \frac{V_0}{K}$

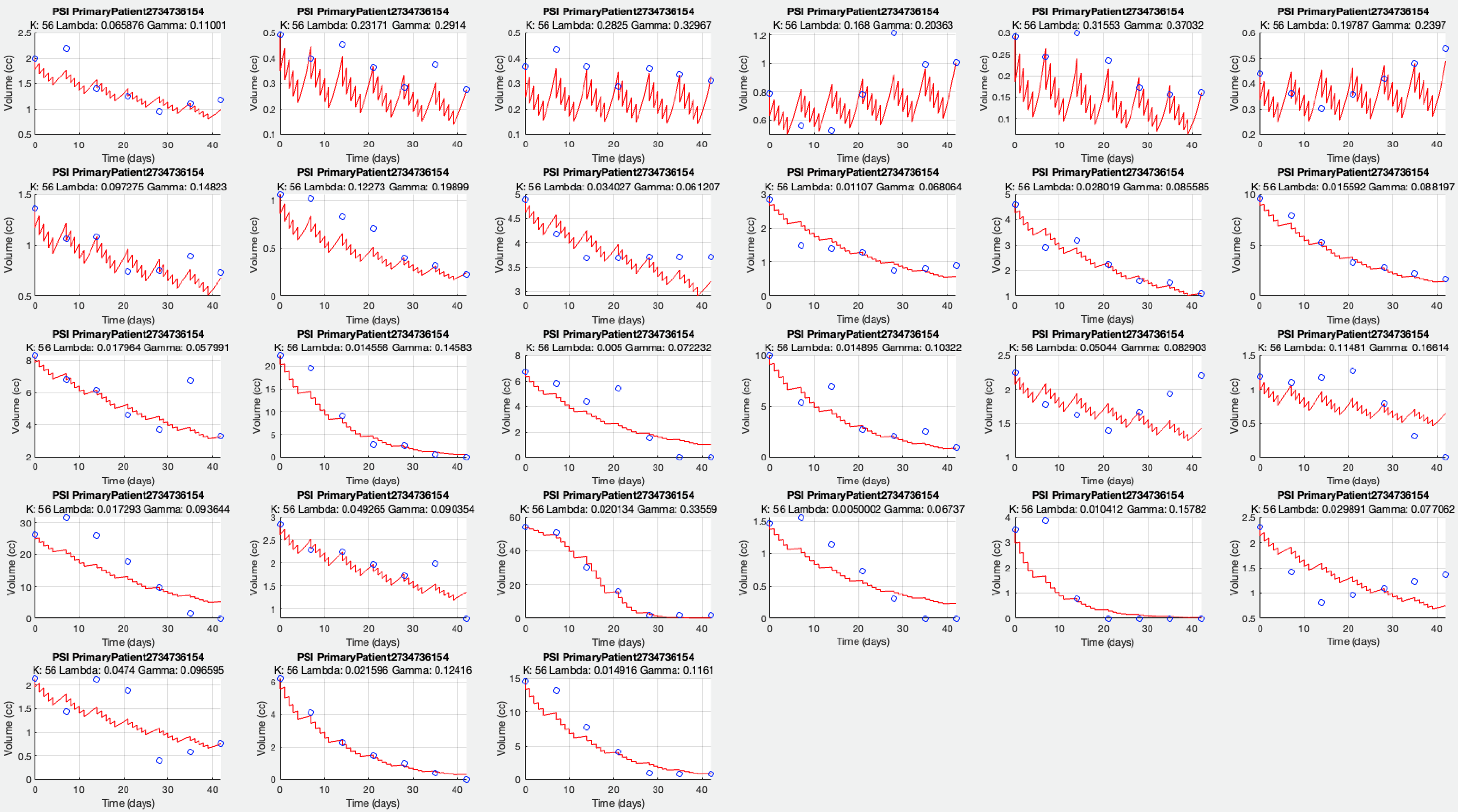
Represents one day of radiation

Represents the weekend

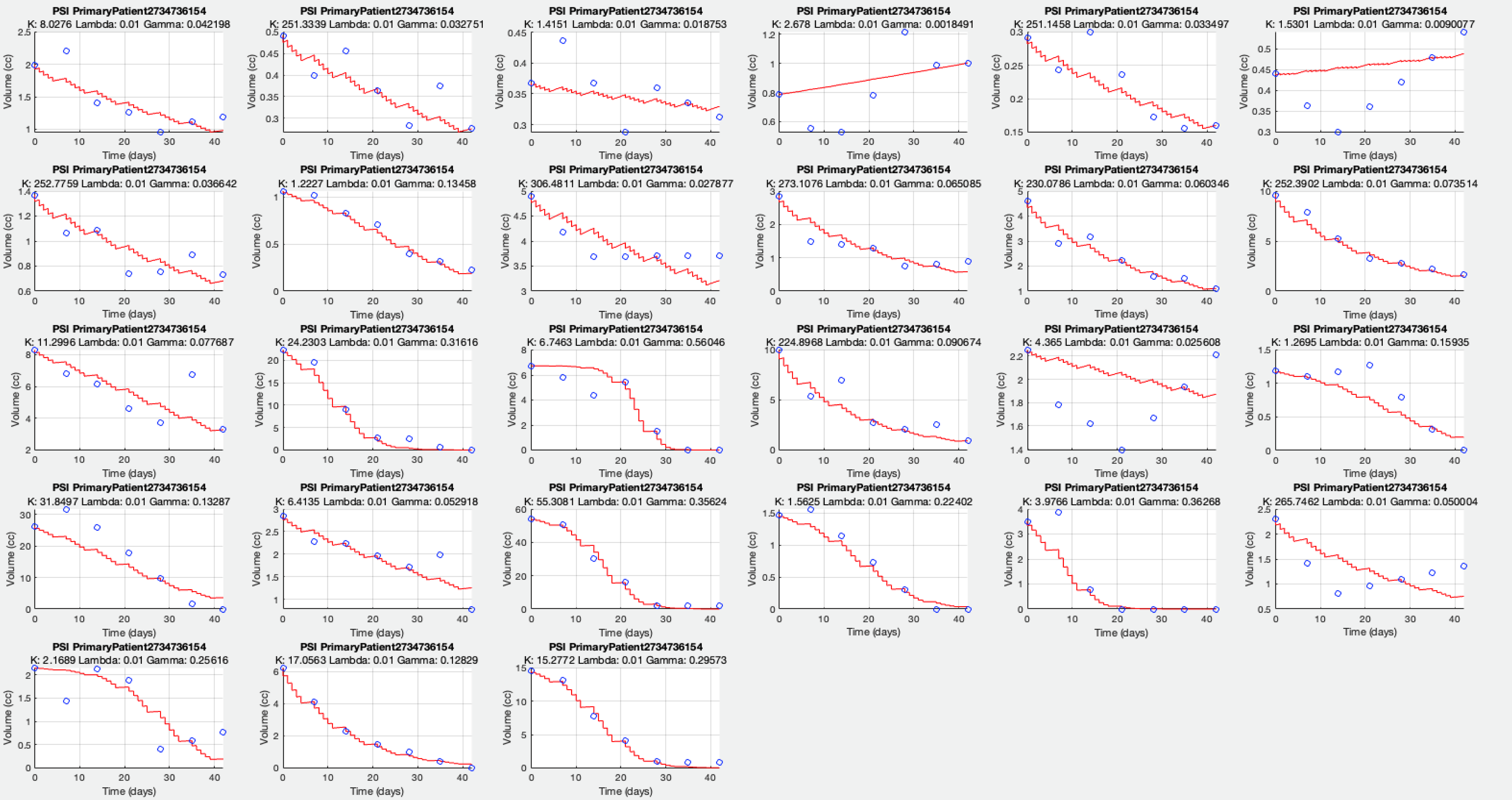
Results: Individualized params



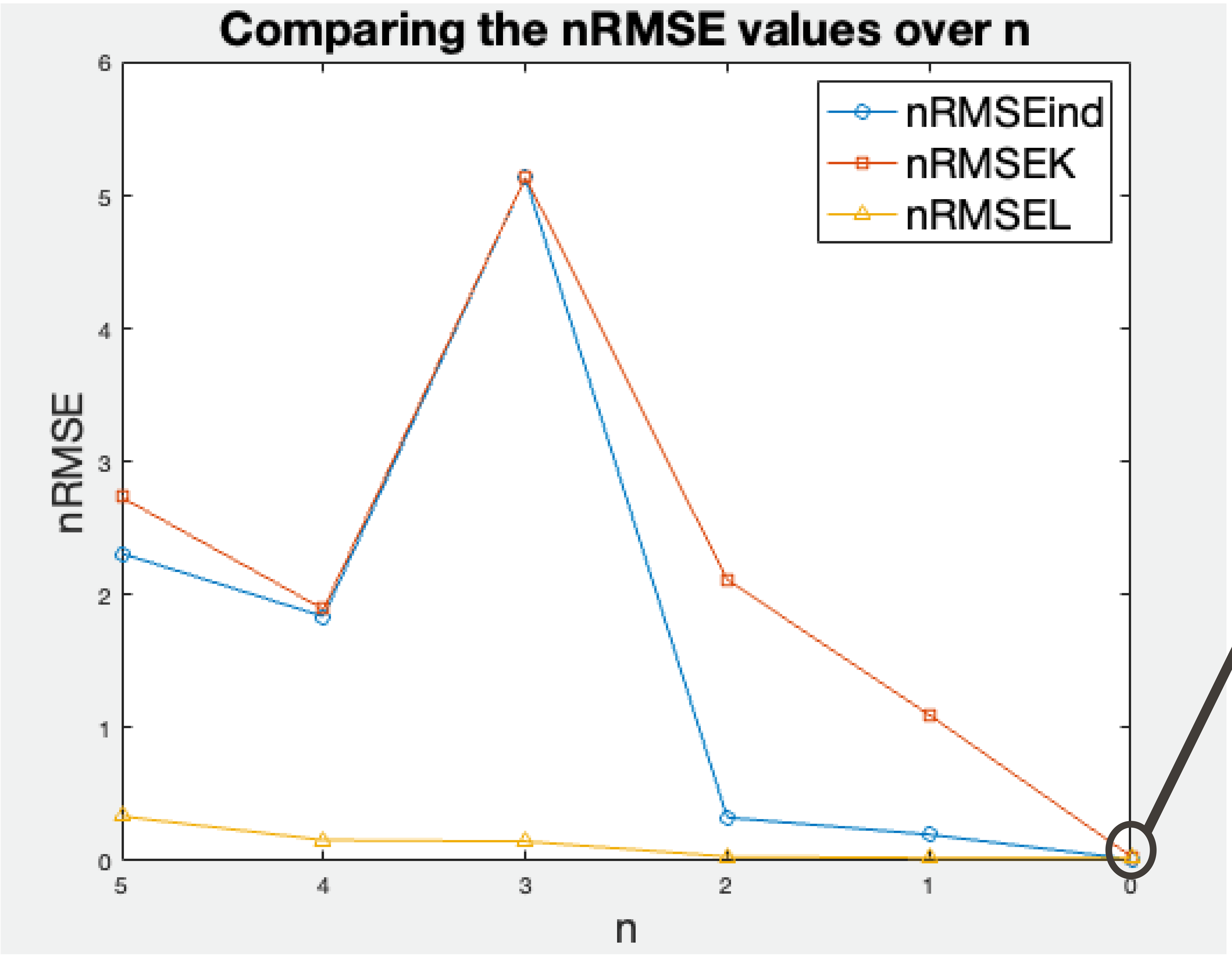
Results: Global K



Results: Global Lambda



Results: Comparing Models



Values without data removed:

Individual Params: 0.014
Global Lambda: 0.024
Global K: 0.034

Results: Comparing Models AICc

P: number of parameters

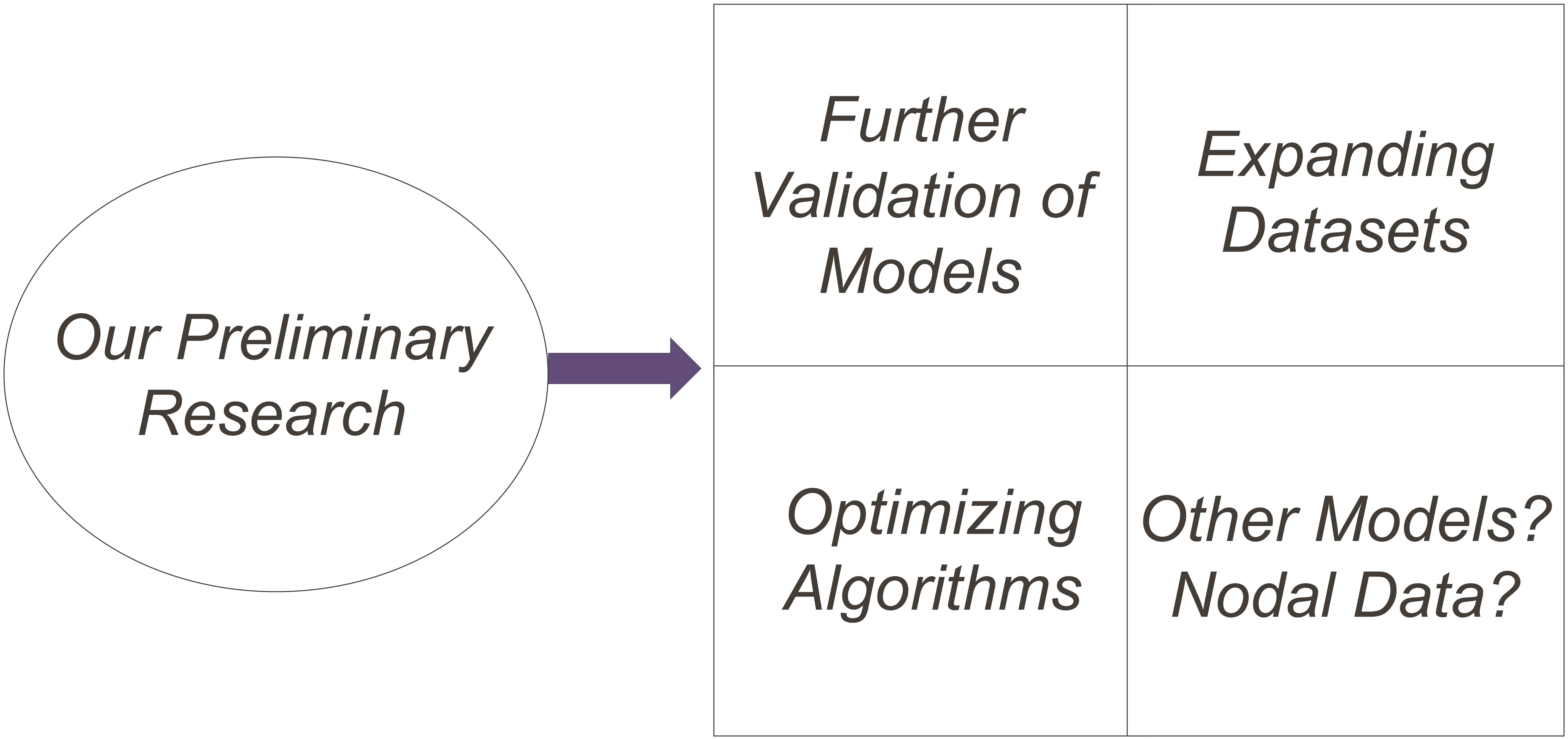
Mean Square Error

n: Number of Data Points

AICc values adjusted for sample size:

Individual Params: 283.5325
Global Lambda: 241.3521
Global K: 309.6008

Next Steps


Our Preliminary Research
Further Validation of Models
Expanding Datasets
Optimizing Algorithms
Other Models? Nodal Data?

Conclusions

The integration of mathematical models in radiation therapy for HNSCC patients holds great potential for enhancing patient outcomes. The model incorporating a global lambda demonstrates the capability of these models to accurately predict treatment responses beyond just a few weeks. By offering a framework to predict individual treatment responses, these models address the challenge of variability in patient reactions, which can lead to improved survival rates and quality of life. Ongoing research and validation using additional datasets and the refinement of global parameters are essential before these models can be adopted in clinical practice.

Acknowledgements

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