Purpose: To determine the optimization objectives that are most critical in prostate IMRT treatment planning, and to demonstrate that clinically acceptable treatments can be obtained using fewer optimization objectives with intelligently chosen importance factors.

Methods: We develop a novel optimization method that uses a historical prostate IMRT treatment as an input to quantify importance factors for a given set of objectives in the treatment planning problem. An initial treatment planning formulation with many candidate objectives is formulated. Then, given a historical treatment, importance factors for the objectives are determined via inverse optimization. We analyzed the results over several patients and identified the most critical optimization objectives in prostate IMRT treatment planning. We then designed a new treatment planning formulation with only the critical objectives, determined the importance factors via inverse optimization, and then compared the dose distribution to that of the original planning problem. The method was applied to a homogeneous cohort of 12 patients from Princess Margaret Hospital.

Results: A treatment plan generated using 18 objectives was replicated using only six objectives and inversely-optimized importance factors. For the bladder and rectum, a combination of the objective that minimizes the mean dose and the objective that penalizes dose above 50 Gy was determined to be most critical, while objectives that minimize the maximum dose were found to be critical for the femoral heads. The bladder and rectum objectives carried more than 95% of the importance factor over all objectives.

Conclusions: By identifying critical objectives, our method has the potential to significantly enhance the computational efficiency of a treatment planning problem. A simplified treatment planning formulation with importance factors that are determined via inverse optimization reduces the need for an iterative, trial-and-error process in treatment planning.