Purpose: To model and predict radiation-induced Sensorineural Hearing Loss (SNHL) from intensity modulated radiation therapy (IMRT) and cisplatin-based chemotherapy for patients with nasopharyngeal carcinoma (NPC).

Methods: Audiometry data of 53 patients (106 ears) treated with the chemoradiation therapy were collected with a median follow-up time of 60 (28-84) months. Among them, 15 SNHL cases were observed. The correlation of the SNHL data with the dose volume histograms (DVH) of both inner ear and cochlea, chemotherapy dose and patient age for each patient were analyzed using the Lyman-Kutcher-Burman (LKB) model and relative seriality (RS) model with a modification to include the impacts from the cisplatin dose and patient age. There are 5 parameters in each model which were determined by a maximal likelihood fitting of the clinical data.

Results: Both models fit the data reasonably well, indicating that SNHL is correlated to the volume and radiation dose to cochlea, thus, to inner ear. This correlation is modified by chemotherapy dose and patient age. TD50(1) is approximately 300 Gy when only radiation is considered and is 72 Gy when patient aging and the cisplatin dose are included. The parameter n and m in the LKB model and s and γ in the SR model were obtained to be n=0.035±0.010, m=0.45±0.11 and s=2.05±1.75, γ =0.71±0.15 averaged over those obtained using DVHs of the cochlea and inner ear. A multivariate analysis found that the normal tissue toxicity probability (NTCP) calculated by the models is a statistically significant factor to predict the ototoxicity rate. The modeling results show that both inner ear and cochlea have the characteristics of a serial organ in terms of radiation dose response.

Conclusions: The biophysical models derived in this study can predict the incidence of SNHL and may be used to optimize radiation treatment plans to reduce SNHL.