Purpose: The accuracy of dosimetric analysis and outcome comparison between conventionally fractionated radiation therapy (CFRT) and stereotactic body radiotherapy (SBRT) requires reliable radiobiological modeling. The aim of this work was to further improve the multi-mode model (MMM) for both CFRT and SBRT.

Methods: MMM assumes the existence of different modes of cell killing as a result of radiation damage to different parts of a cell, e.g., a single severe damage to the DNA or two or more small damages to the membrane or DNA. The cell survival probability can then be calculated by 
\[ s = \prod_{i=1,n} \left( 1 - e^{-(d/D_i)} \right)^{(i)} \],
where \( i \) represents the \( i \)-th mode of cell killing that requires \( i \) potentially unrepairable damages to the cell as a result of radiation dose \( d \) and \( D_i \) is the dose that gives 63% probability to cause an unrepairable damage for the \( i \)-th mode. The dose rate effect is included in MMM assuming \( 1/D_i = (k_i - r_i/U) \), where \( k_i \) is the radiation damage rate, \( r_i \) the repair rate and \( U \) the dose rate. The low-dose hypersensitivity is also included in the new model.

Results: A comparison of the goodness-of-fit of the LQ, multitarget, USC and MMM to the survival curve of the H460 non-small-cell lung cancer cell line showed the same agreement between USC and MMM with the survival data, which was significantly better than the fits to the LQ and multitarget models. The parameters used for the LQ, multitarget and USC models were \( \alpha = 0.33\text{Gy}, \alpha/\beta = 10\text{Gy}, D_T = 6.2\text{Gy}, D_0 = 1.25\text{Gy} \) and \( D_q = 1.8\text{Gy} \). The parameters for MMM \((n=4)\) were \( D_1 = 4.0\text{Gy}, D_2 = 4.01\text{Gy}, D_3 = 3.08\text{Gy} \) and \( D_4 = 41\text{Gy} \).

Conclusions: MMM offers a superior description of the mammalian cell survival curve in both conventional and ablative dose ranges, which can be used for designing new fractionation schemes and predicting and understanding treatment outcomes for both CFRT and SBRT.