Purpose: The aim of this study was to determine the dosimetric impact of heterogeneous cellular uptake of Lu-177 and Y-90 labelled compounds in targeted radionuclide therapy (TRT).

Methods: Fine resolution voxel S values (VSVs) were generated for Lu-177 and Y-90 using Monte Carlo simulation with the EGSnrc user-code DOSXYZnrc. The VSVs were generated to be 20 microns on edge for Lu-177 and 100 microns for Y-90. To simulate varying degrees of heterogeneous uptake, activity was randomly assigned to percentages ranging from 1% to 80% of voxels in cubic volumes chosen to be large enough so that a central region, 30x30x30 voxels in size could receive a cross dose from the maximum beta range of Lu-177 and Y-90. The resulting dose distributions were determined using the VSV approach where each target voxel dose is calculated by summing the product of the activity and corresponding voxel-to-voxel S value from each source voxel.

Results: For the simulated Y-90 activity distribution, when 80% of the 100 micron voxels were labelled, the minimum and maximum voxel doses in the central region of interest were within 2.2% and 1.3% of the mean voxel dose, respectively. A percent difference of less than 10% was maintained between the minimum/maximum and mean voxel dose all the way down to 20% labelling. At 80% labelling of Lu-177, the minimum and maximum voxel doses were within 11.1% and 5.4% of the mean voxel dose, respectively, and at 20% labelling these values increased to 21% and 40%.

Conclusions: This study indicates the impact of nonuniform activity distributions of two commonly used radionuclides in TRT. Even with low percentage labelling, the relatively long range of Y-90 emissions helps to significantly smooth out the dose. The calculated dose distributions were not as uniform for Lu-177 due to the shorter range of its emitted betas.