EVALUATION OF EXPOSURE PATHWAY, INTERNALIZED UPTAKE, AND DOSIMETRY OF THE HUMAN RESPIRATORY TRACT SYSTEM IN DEFENSE AND CONSEQUENCE MANAGEMENT APPLICATIONS

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Dose estimation and reconstruction for internalized radionuclides continues to remain a challenge due to inability to directly measure radionuclide body burden from internalized uptakes. Therefore, estimation of radiation dose exposure relies heavily on mathematical models, notably biokinetic models, to determine biodistribution of radionuclides as a function of time post-exposure. For inhaled radionuclides, reference sex-averaged models have been developed, called the human respiratory tract model (HRTM), which have evolved from deterministic quantities by the International Commission on Radiological Protection (ICRP) in Publication 66 and updated in Publication 130.

In this study, efforts have focused on developing stochastic biokinetic models from inhaled source term intakes as a function of radionuclide inventory and particle size distribution, solubility, and clearance for expanded inhalation coefficients, specific to the exposure source terms from nuclear security events and exposed populations (age/sex-specific). The dose coefficient code, REDCAL, is being developed at Georgia Tech to enhance statistical coupling for uncertainty analysis and to better model particle deposition profiles using Computational Fluid and Particle Dynamics (CFPD) for better representation of anatomical and physiological variations, ultimately to assess radionuclide body burden in defense and consequence management applications. Activity retained in the lung compartments computed with REDCAL with both initial value and eigenvalue approaches were found to demonstrate agreement with historical dose coefficient codes. Furthermore, with identified variable parameters for each module of the computational framework, comparison was conducted for ICRP 66 and ICRP 130 HRTM, where probability distribution functions were developed for eventual implementation of Latin Hypercube Sampling analysis.

Future work to be discussed as part of larger efforts will focus on biokinetic models to predict the behavior pre/post administration of newly developed chelation agents and to generate radiological source-term informed biokinetic and dosimetric dose coefficients for ultimate use with the aid of machine learning, which employs a data-driven regularization approach with less artificial data filtering, for dose reconstruction in individualized monitoring.