Comparison of Latent Bone Modeling and Simple Average Method for Estimating Plutonium Activity Concentration in Human Skeleton

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The United States Transuranium and Uranium Registries (USTUR) holds data from 292 partial-body tissue donors for whom only 2 to 8 bone samples were collected at autopsy and radiochemically analyzed for plutonium. The method currently used at the USTUR to estimate skeleton plutonium activity concentrations, simple average method (SAM), implies that the arithmetic average of collected bone sample concentrations represents the total skeleton concentration. The USTUR also holds data from 14 non-osteoporotic whole-body donors for whom 'true' values of total skeleton plutonium activity concentrations were estimated based on radiochemical analyses of all measured bones from the right side of the skeleton. A recently developed latent bone model (LBM) applies principal components regression (PCR) to reduce uncertainties in plutonium activity concentration estimates from measurements of a limited set of bone samples. This study used a simulation approach to compare accuracy and precision of the LMB and SAM. The analytical bone dataset consisted of measured plutonium concentrations in up to 90 individual bones from 14 non-osteoporotic whole-body tissue donors. For each simulation run, root mean square errors (RMSEs) were determined for the LBM and SAM, and 10,000 simulations were run for a given number of individual bones (2 to 5). The distributions (mean and standard deviation) of RMSEs obtained from the 10,000 simulations were used to compare accuracy and precision of the LBM and SAM. The results showed that the LBM approach significantly improved the total skeleton concentration estimates. The relative mean (accuracy) reductions of the LBM vs. SAM were 55.5%, 57.4%, 59.1%, and 60.4%; relative standard deviation (precision) reductions were 65.2%, 66.6%, 67.9%, and 68.6% for 2, 3, 4, and 5 bone samples, respectively.

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