A Method for Calculating Bayesian Uncertainties on Internal Doses Resulting from Complex Occupational Exposures

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Estimating uncertainties on doses from bioassay data is of interest in epidemiology studies that estimate cancer risk from occupational exposures to radionuclides. Bayesian methods provide a logical framework to calculate these uncertainties. However, occupational exposures often consist of many intakes, and this can make the Bayesian calculation computationally intractable. This paper describes a novel strategy for increasing the computational speed of the calculation by simplifying the intake pattern to a single composite intake, termed as complex intake regime (CIR). In order to assess whether this approximation is accurate and fast enough for practical purposes, the method is implemented by the Weighted Likelihood Monte Carlo Sampling (WeLMoS) method and evaluated by comparing its performance with a Markov Chain Monte Carlo (MCMC) method. The MCMC method gives the full solution (all intakes are independent), but is very computationally intensive to apply routinely. Posterior distributions of model parameter values, intakes and doses are calculated for a representative sample of plutonium workers from the United Kingdom Atomic Energy cohort using the WeLMoS method with the CIR and the MCMC method. The distributions are in good agreement: posterior means and $Q0.025$ and $Q0.975$ quantiles are typically within 20 %. Furthermore, the WeLMoS method using the CIR converges quickly: a typical case history takes around 10–20 min on a fast workstation, whereas the MCMC method took around 12–72 hr. The advantages and disadvantages of the method are discussed.

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