Uncertainty in Internal Doses: Using Bayes to Transfer Information from One Worker to Another

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Uncertainty in the estimates of internal doses to workers or members of the public can arise for a variety of reasons, which include a lack of knowledge about assumed model parameters, uncertainty in exposure conditions, paucity of measurement data, and variability between individuals. In some cases, for example, causation or epidemiological studies, it is essential to be able to quantify this uncertainty for each individual in the study.

Over the past few years, a simple, yet powerful method employing Bayesian inference has been developed to evaluate directly the uncertainties in doses for individuals exposed to radionuclides. It is proposed to use this methodology to estimate uncertainties in lung and bone marrow doses for several thousand nuclear power workers in the UK, France and Belgium, as part of a large European epidemiological study (Alpha Risk) aimed at quantifying the risk from alpha irradiation. It is also planned to extend this methodology to improve the quality of dosimetric data for members of the Mayak Worker and Techa River Cohorts in the Southern Urals, as part of a large European Project (SOUL).

It is often the case that some individuals within a cohort will have been subject to extensive measurements, enabling precise estimates of organ doses to be derived, while for others, the measurement data is sparse. The question is, how can one make use of the measurement data on the former individuals, to improve dose estimates for the latter? It will be seen that Bayes provides the very mechanism for doing this, since the essence of the Bayesian approach is to start with knowledge before the measurement data are known (prior knowledge), and then use the measurement data to revise it (posterior knowledge).

The aim of this paper is to illustrate our Bayesian method by taking two such cases, who were both exposed by accidental inhalation of the same form of americium compound. Essentially, the comprehensive bioassay data available for the first worker is used to derive posterior probability distributions of absorption parameters for the americium material which are used as prior information to improve the dose assessment for the second worker. Direct assessment of the uncertainty in the second worker's dose, both with and without the additional information from the first worker, quantifies the improvement in dose assessment obtained. A simple method of dealing with correlations between critical model parameters in this case is proposed, and its wider implications are discussed.

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