The Treatment of Uncertainty in Compensation Schemes for Cancer Based on the Probability of Causation Methodology

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INTRODUCTION
Since it is commonly accepted that exposure to ionizing radiation, even at the low levels encountered in the workplace, can cause malignant diseases\(^{(1,2)}\), radiation workers are at some risk, although much is done to optimize radiation protection and reduce occupational exposure to levels "as low as reasonably achievable". However, the causal relationship between exposure to radiation and malignant diseases is difficult to establish, since cancer is such a frequent disease and many other factors may contribute to its development. Ideally, those workers who developed cancer as a result of occupational exposure to radiation should be compensated. Guidance on procedures and methodology to assess attributability of cancer to occupational exposure to radiation and to assist decision-making in compensating workers is provided in a recent joint IAEA/ILO/WHO publication\(^{(3)}\). This guide also reviews compensation schemes in place in several countries, with an emphasis on those based on the probability of causation (POC), also known as assigned share (AS) methodology. The POC method provides a scientifically based framework to assess cancer attributability to occupational exposure and was extensively reviewed by Wakeford et al\(^{(4)}\). This paper presents a comparison of two well-known compensation schemes based on the POC approach with regard to their treatment of uncertainty.

UNCERTAINTY IN POC ESTIMATION
The sources of uncertainty are uncertainty inherent in the dosimetry data and uncertainty in the risk models. Uncertainty in the dose estimates are due to the degree of accuracy in the dosimetry records, to the fact that a whole-body dose is often used instead of the relevant organ dose which has not be monitored, to the fact that organ doses due to internal exposure are estimated from bioassay measurements. If dosimetry records are not available, a large degree of uncertainty is introduced by the process of dose reconstruction. The cancer risk models were mostly derived from the epidemiological studies conducted on the survivors of the atomic bombings of Japan. Uncertainty in the risk models is due to uncertainty in the dose estimates of the survivors and to various other factors, such as the method for transferring risk from the Japanese population to another population and the inclusion of a dose and dose rate effectiveness factor (DDREF).

TREATMENT OF UNCERTAINTY IN THE UK COMPENSATION SCHEME
The Compensation Scheme for Radiation Linked Diseases (CSRLD) is in place in the UK since 1981, as an agreement between employers in the nuclear industry and trade unions\(^{(4)}\). Its estimation of POC is based on the risk models presented in BEIR VII, which are mostly derived from the latest analysis of the epidemiological data collected from the Japanese survivors. Uncertainty in the dosimetry data is dealt with by constructing dose histories by retrospectively applying current assessment standards to historical dose records\(^{(3)}\). Uncertainty in the calculation is not formally taken into account through a quantitative uncertainty analysis, but it is believed that this uncertainty is overcome by adopting a proportional recovery compensation system. Under this system claimants with POC values of 50% or above are fully compensated, but claimants with POC values below 50% are also partially compensated according to the following sliding scale: \(1/4\) of full compensation for POC values between 20-
29.9%, ½ for values between 30-39.9% and ¾ for values between 40-49.9%. It is believed that this system ensures that no deserving claimant is denied compensation.

TREATMENT OF UNCERTAINTY IN THE USDOE COMPENSATION PROGRAM
The program was enacted in the US under the Energy Employees Occupational Illness Compensation Program Act (EEOICPA) of 2000. It is designed to provide compensation to the nuclear weapons production workers employed by the USDOE and its contractors, who developed cancer as a result of their occupational exposure.
Use is made of the radioepidemiological tables developed by the US National Institutes of Health (NIH), as periodically updated and implemented in the Interactive RadioEpidemiological Program (IREP) computer software. These tables are also based on epidemiological data derived from the Japanese atomic bombs survivors.
The method incorporates formal uncertainty analysis by describing the uncertainty in each of the parameters mentioned above by a subjective probability distribution and propagating these uncertainties through a Monte Carlo type calculation to obtain the full probability distribution of the POC (instead of its central estimate in the UK scheme).
Compensation is awarded if the POC value is 50% or above, but instead of using the central estimate of the POC, the EEOICPA mandates the use of the upper 99% confidence limit of its distribution.

CONCLUSIONS
Although the treatment of uncertainties in the USDOE Compensation Program is more formal and scientifically based than in the UK Compensation Scheme, the political decision to mandate by law the use of the upper 99% confidence limit of the POC distribution introduces some partiality: on one hand it ensures that no deserving claim would be denied, but on the other hand it may allow many non-deserving claims to be successful. The treatment of uncertainties in the UK Compensation Scheme, through the introduction of proportional recovery at POC values lower than 50%, seems therefore more balanced.

REFERENCES