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Contract number:
Food-CT-2004-506446

Safe Foods

Integration of probabilistic exposure assessment and probabilistic hazard characterization and some applications

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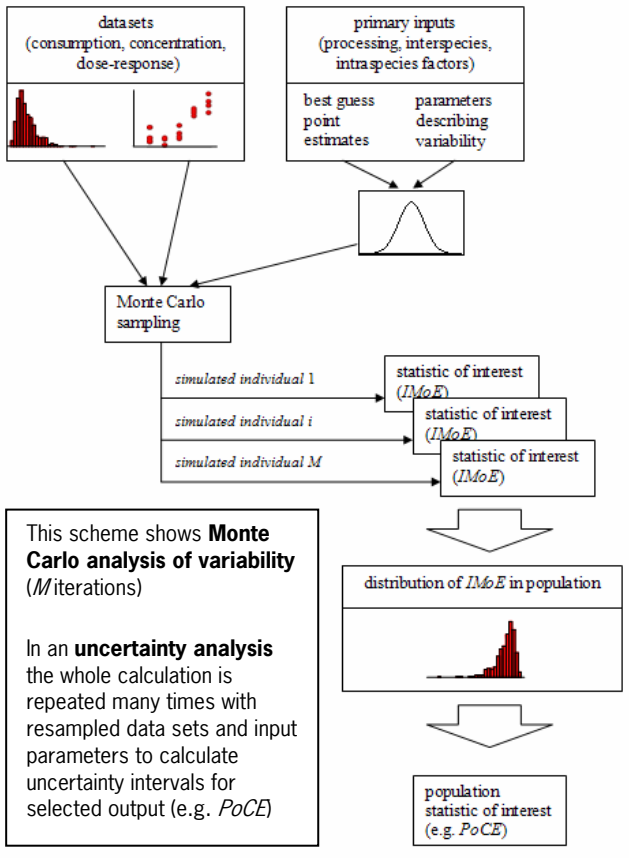
A method is proposed for **integrated probabilistic risk assessment** where exposure assessment and hazard characterization are both included in a probabilistic way. The aim is to specify the probability that a random individual from a defined (sub)population will have an exposure high enough to cause a particular health effect of a predefined magnitude, the ***critical effect size* (*CES*)**. The exposure level which results in exactly that *CES* in a particular person is the person's ***individual critical effect dose* (*ICED*)**.

Individuals in a population typically show variation, both in their ***individual exposure* (*IEXP*)** and in their *ICED*. Both the variation in *IEXP* and the variation in *ICED* are quantified in the form of probability distributions. Assuming independence between both distributions, they are combined (by Monte Carlo) into a distribution of the ***individual margin of exposure* (*IMoE*)**, where *IMoE* = *ICED* / *IEXP*.
The proportion of the *IMoE* distribution below unity is the ***probability of critical exposure* (*PoCE*)** in the particular (sub)population. Low percentiles of the *ImoE* distribution may also be used as risk indicator.

Calculation scheme Integrated Probabilistic Risk Assessment:

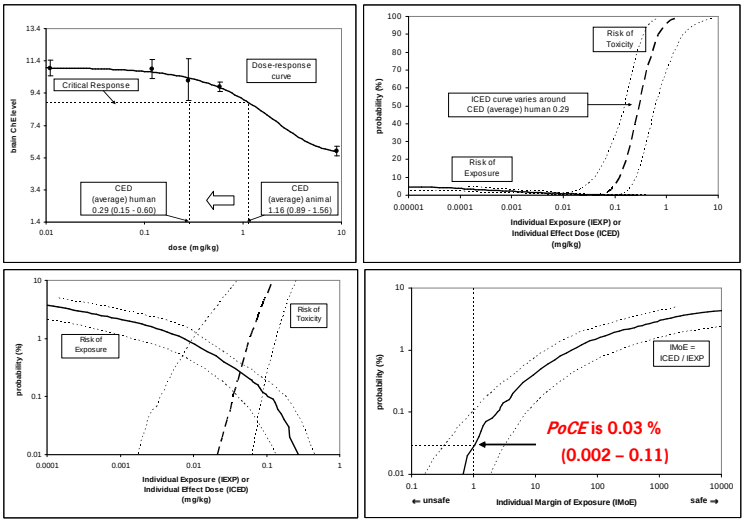


This scheme shows **Monte Carlo analysis of variability** (*M* iterations)

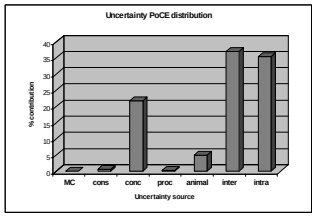
In an **uncertainty analysis** the whole calculation is repeated many times with resampled data sets and input parameters to calculate uncertainty intervals for selected output (e.g. *PoCE*)

Example 1. Acute risk assessment. Organophosphate acephate (concentration data multiplied by 100), critical effect size: 20 % cholinesterase (ChE) inhibition. Exposure calculated for Dutch population. The plots summarise the probabilistic results, retaining the distinction between variability and uncertainty.

The risk for an individual of being exposed to a certain dose decreases with increasing dose, but the risk to experience toxic effects due to this dose increases; The distribution of the Individual Margin of Exposure (IMoE) in the population can be quantified:



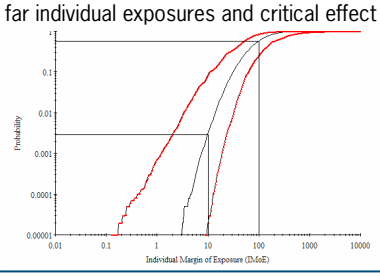
Uncertainties involved in the overall risk assessment (i.e., both regarding exposure and effect assessment) are quantified using Monte Carlo and bootstrap methods. This results in an uncertainty distribution for any statistic of interest (here *PoCE*). The relative contributions from various sources of uncertainty involved can be quantified.



Uncertainty contributions

Lack of knowledge on interspecies and intraspecies factors and lack of sufficient concentration data contribute most to the uncertainty about *PoCE*

Example 2. Chronic risk assessment. Mycotoxin DON (preliminary data), Critical effect size: 5 % reduced body weight gain. Exposure Dutch children (age 1-14) calculated with BetaBinomial-Normal model for usual intake. In this example the Probability of Critical Exposure (*PoCE*) is small, so also the probabilities of not exceeding higher *IMoE* levels and low *IMoE* percentiles are evaluated to indicate how far individual exposures and critical effect doses are apart.



Prob (*IMoE* ≤ 1) = 0 % (0 – 0.07) [***PoCE***]
Prob (*IMoE* ≤ 10) = 0.3 % (0.002 - 8)
Prob (*IMoE* ≤ 100) = 57 % (25 – 86)

IMoE 1st percentile = 14 (3.3 – 32)
IMoE 0.1th percentile = 8 (1.2 – 19)

Reference: van der Voet, H. and Slob, W. (2007). Integration of probabilistic exposure assessment and probabilistic hazard characterization. *Risk Analysis*, 27: 351-371.

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