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:

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.

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)