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A Primer: Deterministic vs. Probabilistic Approaches to Estimating Exposure

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A **deterministic** approach means that for each term in an equation there is only one value and the result of the equation is also a single value. Thus each value and the resultant answer are entirely determined (hence a “deterministic” approach).

A deterministic approach for exposure from the consumption of a food would be:

$$\text{Exposure} = [\text{Concentration of a chemical in a food}] * [\text{Amount of the food eaten}]$$

If this food is salmon, an assessor may ask: "What was the concentration of chemical A in salmon?" The answer will typically be “each salmon has a different concentration”. The available monitoring data for salmon shows there are lots of different values--sometimes orders of magnitude apart. In addition, some salmon may have no chemical A in them. BUT in a deterministic analysis the assessor must pick just one number to represent the value of the concentration in salmon.

Should the assessor use the average concentration? Should they use the highest value? The median? The 99.9th, or 95th percentile? Or some other point on the distribution of values? No matter which number the analyst picks, a single number will always to some extent be “wrong” since it can not capture the reality that the number is different in each fish.

In the second half of the equation “Amount of the food eaten” the analyst encounters the same problem. In the general U.S. population, any subpopulation, or even in any room full of people, if that analyst asks "How much salmon did you eat today?" They will receive different answers from each person. Each person has a slightly (or radically) different diet. Some people may eat no salmon at all, and some may eat a lot of salmon very frequently. Again, the analyst can choose only one value to answer the question: "How much salmon is eaten?"

The answer for the exposure to A that is produced by a determinist approach is a single answer. This answer may be correct for a few of the individuals in the population but will be wrong for most and will either under or over estimate their exposures.



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A **probabilistic** approach uses all of the values for each of the terms in the equation. So for the same equation:

$$\text{Exposure} = [\text{Concentration of a chemical in a food}] * [\text{Amount of the food eaten}]$$

the assessor can "line up" all of the possible values of the concentration of chemical A in salmon and "line up" all of the answers to the amount of salmon eaten. Then the analyst uses a computer to multiply each of the values of concentration times each of the values of amount eaten¹.

This yields lots of answers for the question what is the exposure to chemical A. In fact, we now have a "distribution" of exposure answers. This distribution creates a profile of the possible exposures across the population. This profile provides a lot of opportunity to the decision maker. You can see the maximum answer, you can see the proportion of the population that has no exposure, and you can see everything in between. But, because there are so many answers, the assessment is more complex than many are used to seeing, but it give a more honest and complete description of the reality of how exposures can vary across individuals.

¹ Or the computer may randomly select values from each list to multiply.