# COMPARATIVE PROBABILISTIC RISK ASSESSMENT OF OCHRATOXIN A IN MOROCCAN CEREAL PRODUCTS

*“Probabilistic risk assessment allows us to see not just what exposure might occur, but how often and to whom.”*

MOEZ SANAA

PRESENTATION

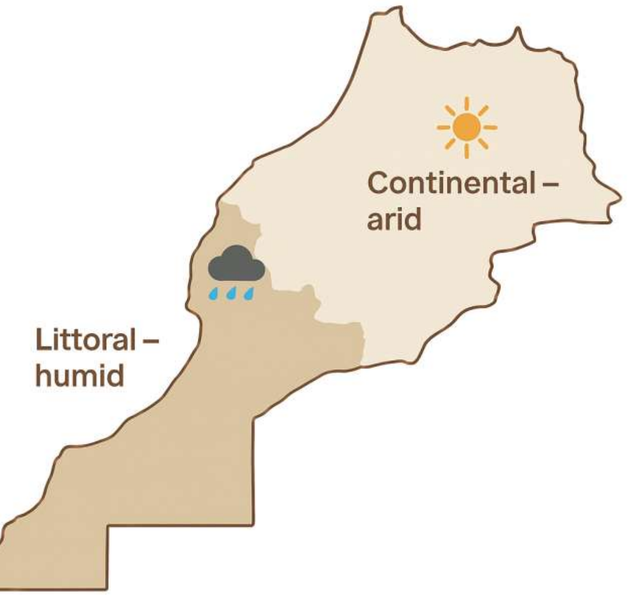
THE FUTURE OF PRA

# CONTEXT

*“In a country where bread is not just food but culture, each loaf becomes a potential exposure vector.”*

- **Ochratoxin A (OTA): mycotoxin from Aspergillus & Penicillium.**
- **Nephrotoxic, possibly carcinogenic (IARC 2B).**
- **JECFA PTWI: 100 ng/kg BW/week.**
- **Moroccan diets: 185 kg cereals per person/year.**

# OBJECTIVE & STUDY DESIGN




- Compare OTA exposure from bread, pasta, semolina between Littoral (humid) & Continental (arid) regions.
- “Two climates, one staple diet - how does environment shape our risk?”

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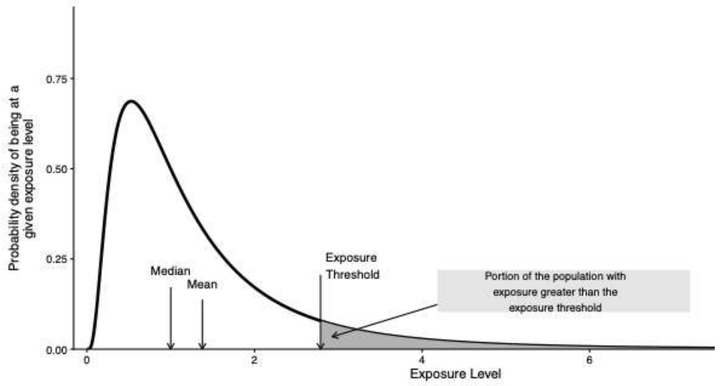
# CONCEPTUAL FRAMEWORK




$$EWI = \frac{\sum_i C_i \times Q_i}{BW}$$

*“Deterministic models give us a number; probabilistic models give us a story.”*

- Exposure = Σ(Contamination × Consumption) / Body weight
- Deterministic: fixed means or percentiles
- Probabilistic: distributions & resampling

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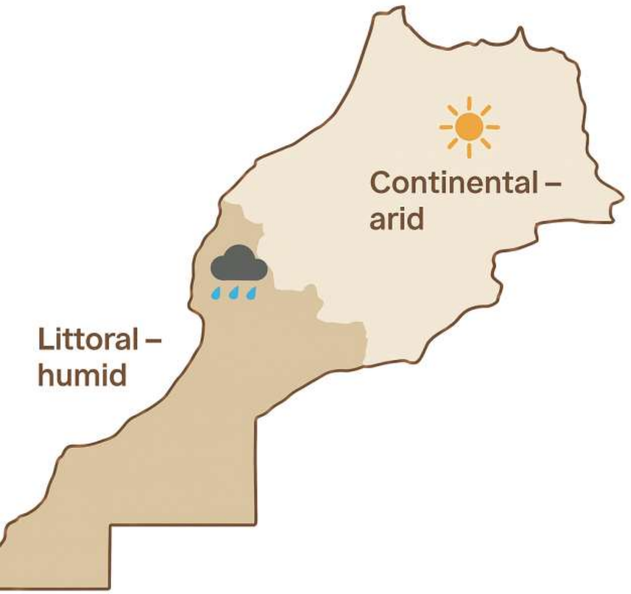
# DATA FOUNDATION

- 226 samples of cereal derivatives.
- 474 individual consumption surveys.
- OTA up to 14.1 µg/kg detected.

# DATA FOUNDATION

Bread = main contributor (> 85%).




| Region | Median (ng/kg b.w./wk) | 95th perc. | % of PTWI |
|---|---|---|---|
| Littoral | 48.97 | 114.3 | 114 % |
| Continental | 6.36 | 18.2 | 18 % |

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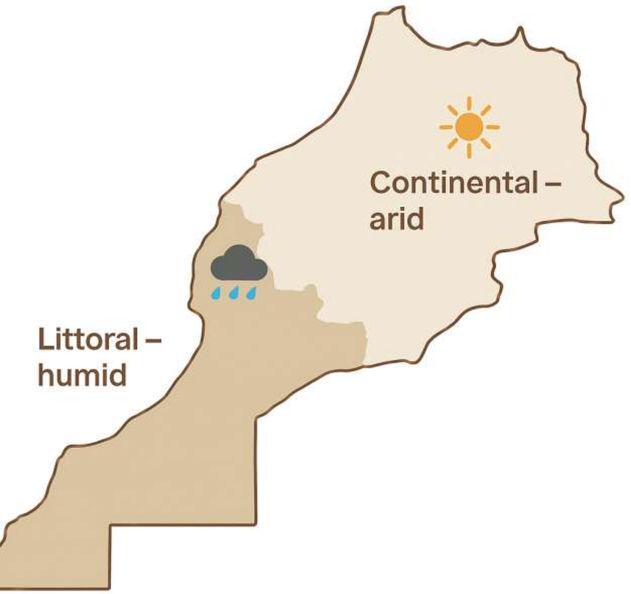


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# DETERMINISTIC ESTIMATES

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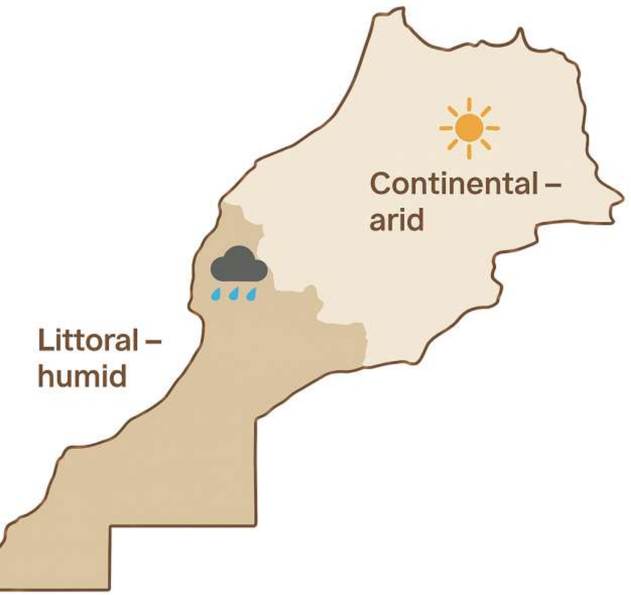



$$EWI = \frac{\sum_i C_i \times Q_i}{BW}$$

| Sampling Area | Cereal Derivative | P25 | P50 | Mean | P75 | P95 |
|---|---|---|---|---|---|---|
| Littoral | Bread | 37.71 | 45.26 | 52.33 | 56.57 | 103.7 |
| | Semolina | 1.40 | 3.20 | 3.95 | 6.40 | 8.69 |
| | Pasta | 0.26 | 0.51 | 0.70 | 0.90 | 1.93 |
| | Total EWI | 39.37 | 48.97 | 56.98 | 63.87 | 114.3 |
| Continental | Bread | 1.43 | 1.71 | 1.98 | 2.14 | 3.93 |
| | Semolina | 1.33 | 3.05 | 3.76 | 6.10 | 8.28 |
| | Pasta | 0.80 | 1.60 | 2.18 | 2.80 | 6.00 |
| | Total EWI | 3.56 | 6.36 | 7.92 | 11.04 | 18.21 |
| *p*-value [1] | | 0.0013 | 0.009 | 0.019 | 0.017 | 0.027 |

[1]: *p*-value between littoral and continental EWI for the different percentiles (P25, P50, P75 and P95) and the mean.

# Variability vs Uncertainty - The Concept

- Variability: natural differences among consumers.
- Uncertainty: limited knowledge about contamination and data.

*“Variability is who we are; uncertainty is what we don’t yet know.”*

# PROBABILISTIC APPROACH

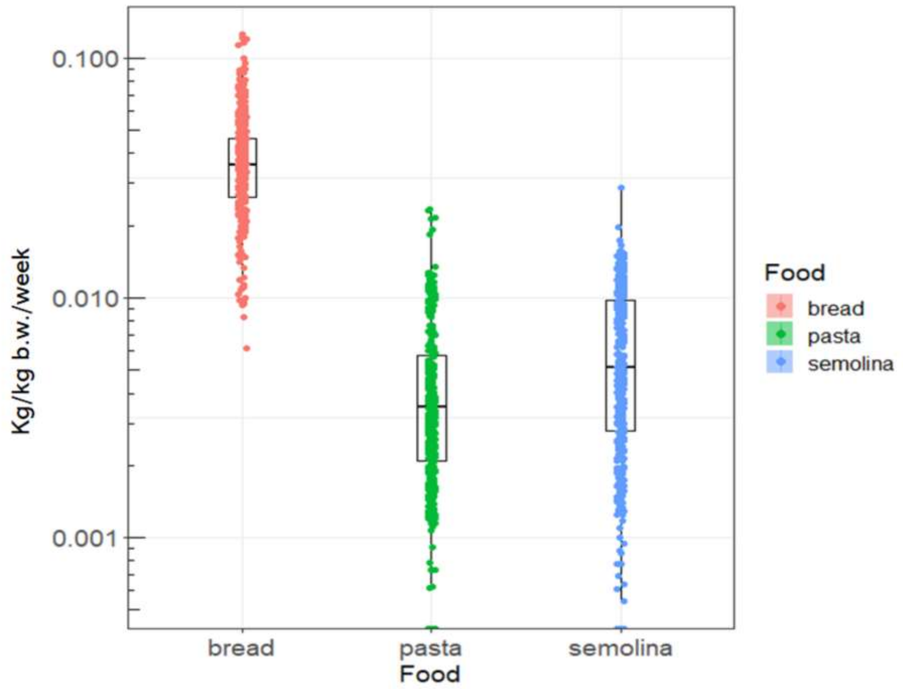



**Figure 1.** Distribution of weekly consumption (Kg/kg b.w./week) of cereals derivatives observed the littoral region.

**Table 1.** OTA levels (µg/Kg) in analyzed cereal derivatives samples.

| Sampling Area | Cereal Product | Sample Size | Minimum | Mean UB [1] | Maximum |
|---|---|---|---|---|---|
| Littoral | | | | | |
| | Bread | 44 | 0.02 | 1.32 ± 0.53 | 7.2 |
| | Semolina | 32 | 0.02 | 0.64 ± 0.34 | 3 |
| | Pasta | 32 | 0.02 | 0.18 ± 0.12 | 1.1 |
| | | | | 0.82 ± 0.06 [2,3] | |
| Continental | | | | | |
| | Bread | 46 | 0.02 | 0.05 ± 0.03 | 0.5 |
| | Semolina | 45 | 0.02 | 0.61 ± 0.80 | 14.13 |
| | Pasta | 27 | 0.02 | 0.56 ± 0.26 | 2.1 |
| | | | | 0.36 ± 0.01 [2,3] | |

[1] Mean contamination level obtained under a high hypothesis (Upper Bound: UB) was retained because no statistical difference was observed between mean UB and mean LB (Lower Bound). [2] Average contamination of the three cereal derivatives. [3] Significant difference ($p$-value = 0.0062) between the mean contamination levels (littoral versus continental).

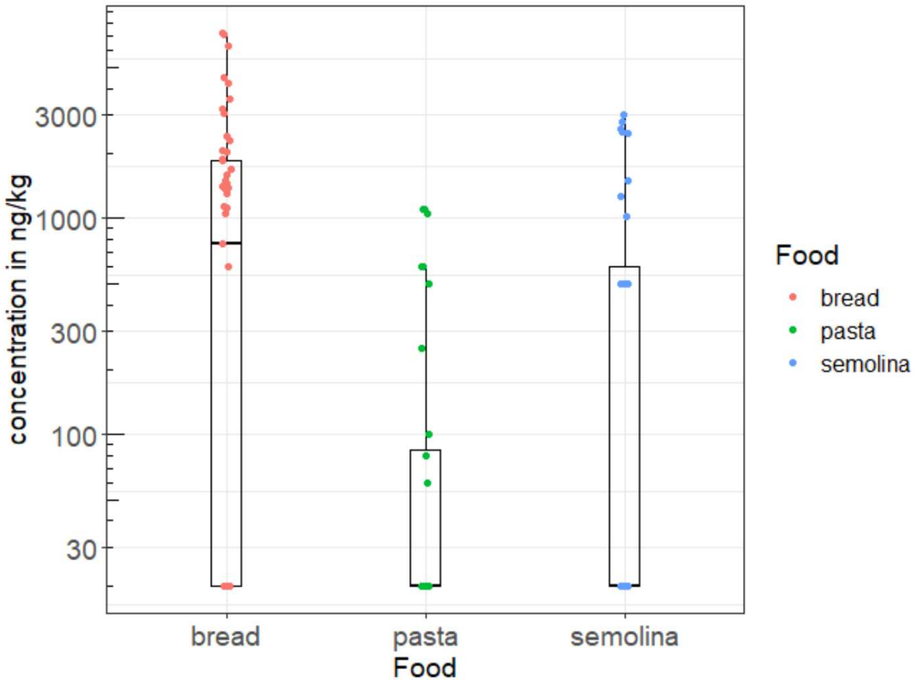



**Figure 2.** Distribution of OTA concentrations (ng/kg) observed in the littoral region.

# PROBABILISTIC APPROACH

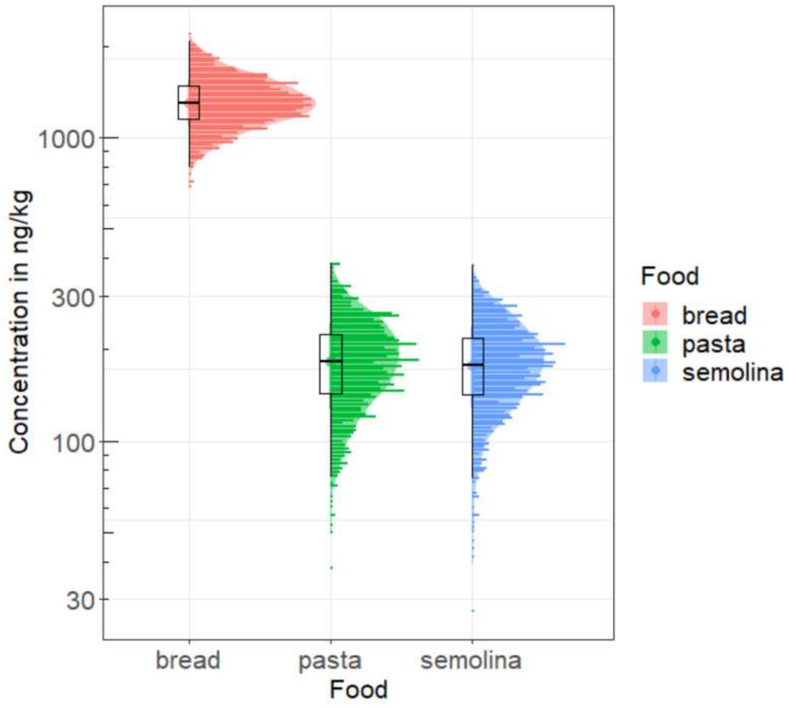


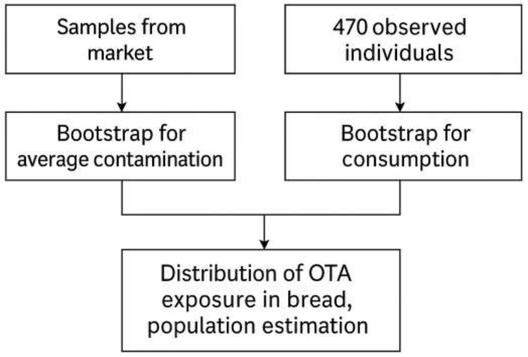

**Figure 3.** Distribution of average OTA concentrations (ng/kg) for the three cereal derivatives obtained with the 1000 draws with presentation of the results observed in in the littoral region.

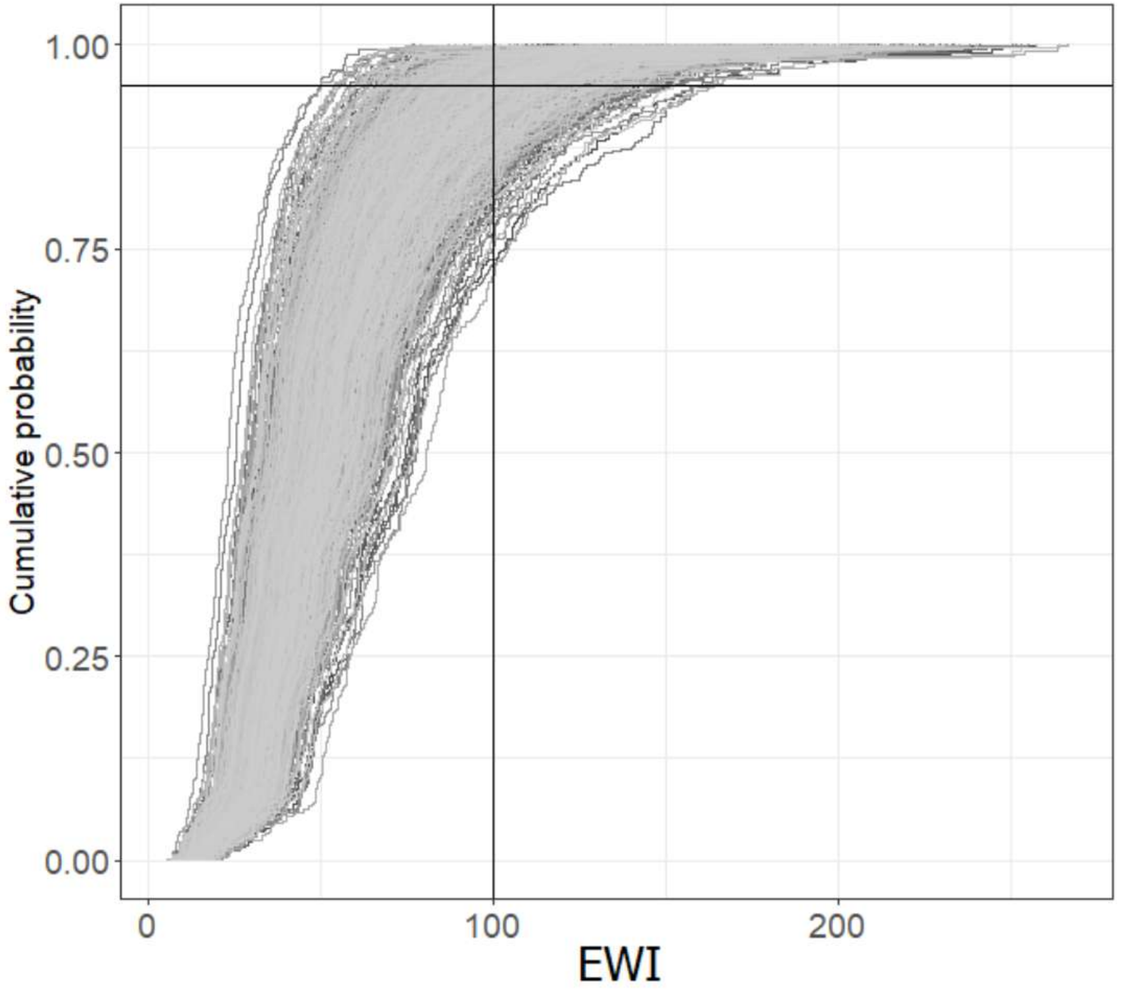
**1,000 bootstrap draws of OTA concentrations.**
**Each draw = new estimation of the contamination average**

**The distributions show the uncertainty about the average level of contamination**

## Concept of Bootstrapping

- Bootstrapping is a resampling method used to estimate how much results could vary if we had new data.
- Instead of collecting new samples, we reuse the existing dataset many times by randomly resampling with replacement (meaning each data point can be chosen more than once).
- Each resample gives a slightly different estimate (e.g., average contamination level).
- After many repetitions (often 1,000 or more), we obtain a distribution of possible averages rather than a single number.




*“Each curve is a world that could exist, together they define the envelope of our confidence.”*

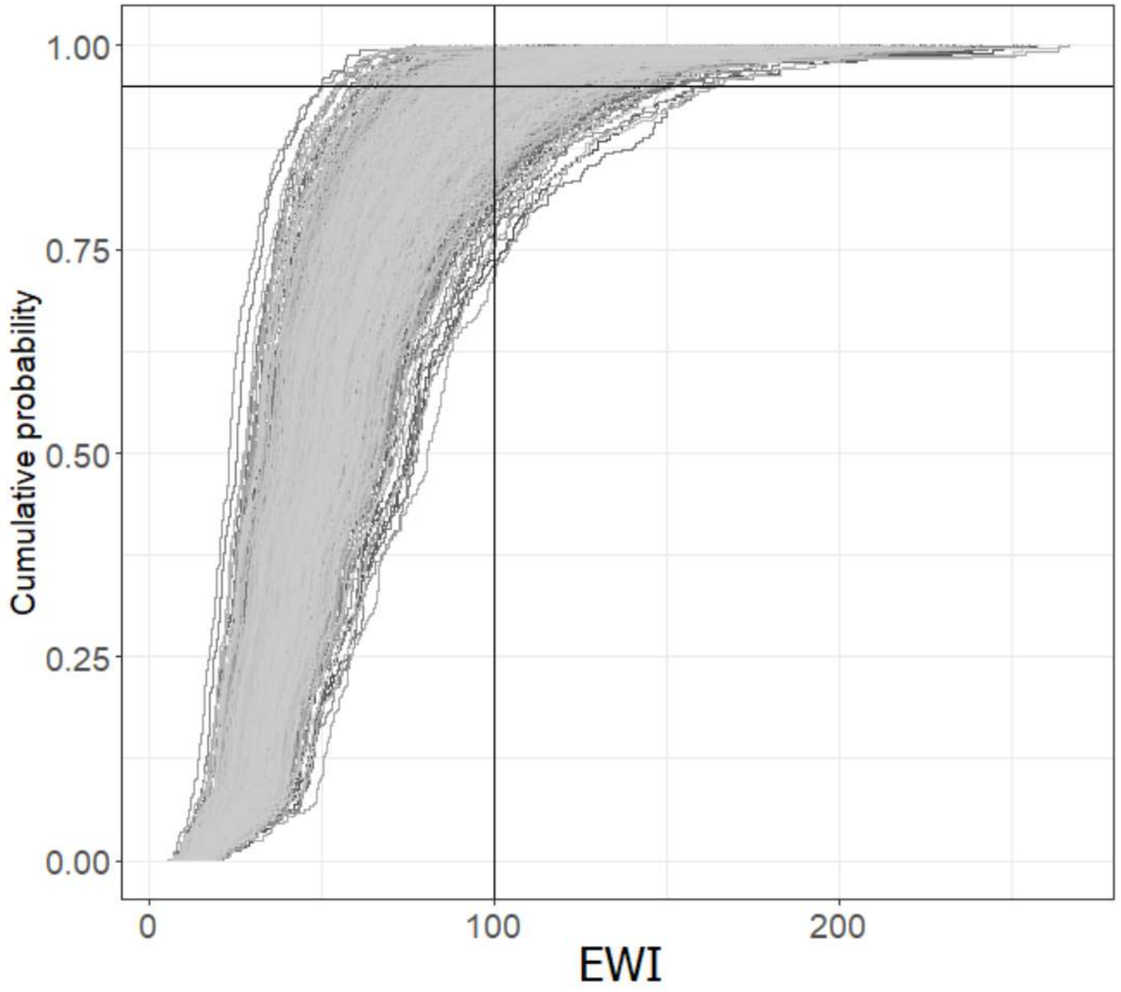



**Figure 4.** Cumulative distribution of EWI—Probabilistic approach.

## Probabilistic estimates

**Exposure percentiles (ng/kg BW/week):**

- P50 = 48.2 [32.6–67.4]
- P75 = 61.8 [42.6–86.4]
- P95 = 97.4 [66.2–137.8]

**Exceedance of PTWI: 0.4–17.3% (median 4.4%)**

## Deterministic estimates

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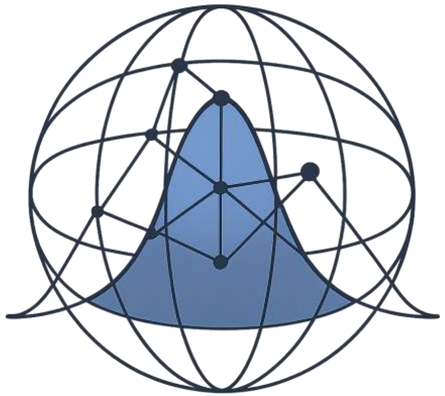
# COMPARISON OF APPROACHES



Deterministic = simpler, blind to extremes.
Probabilistic = computationally heavy, decision-relevant.

“Regulators need not certainty, but clarity - probabilistic analysis provides that clarity.”

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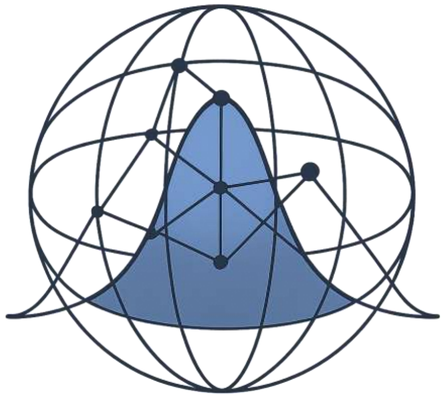
# KEY FINDINGS



Littoral exposure 7× higher than continental.

Bread drives OTA exceedance.

Probabilistic analysis reveals hidden exceeders.

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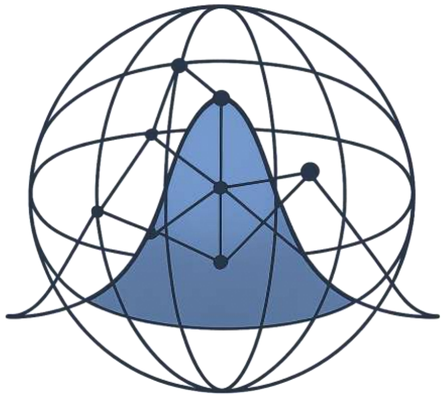
# CONCLUSION



- Bread is the key OTA exposure source, especially in humid coastal regions.
- Probabilistic modeling reveals real-world variability, showing about 4–5 % (Best estimate) of consumers exceed the PTWI.
- Climate and storage conditions drive contamination, making regional risk differentiation essential.
- Probabilistic assessment improves policy relevance, guiding realistic OTA limits and prevention strategies.

*““Probabilistic modeling reinforces each layer; sound science, open communication, credible policy.”*

MOEZ SANAA

# THANKS